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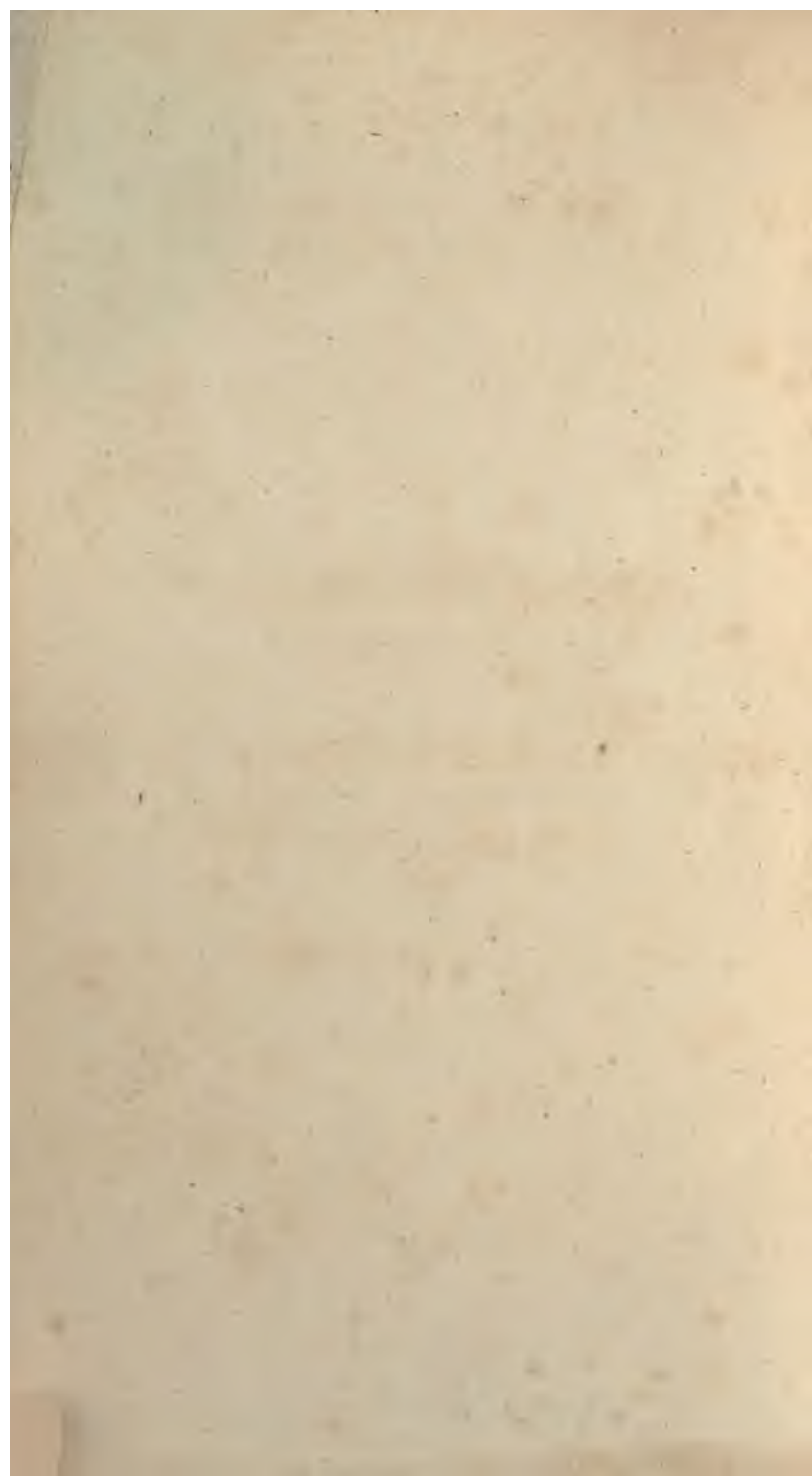


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A
GENERAL SYSTEM
OR
CHEMICAL KNOWLEDGE,
&c. &c.

A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,
Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.
TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,
BY WILLIAM NICHOLSON.



VOL. X.

LONDON:

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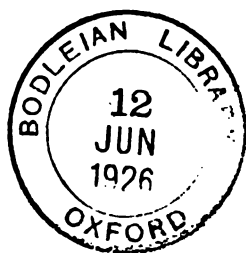


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A
S Y S T E M
OF
CHEMICAL KNOWLEDGE.

CONTINUATION

OF THE

EIGHTH SECTION.

Concerning the Animal Substances.

ARTICLE XX.

Of the Gastric and Pancreatic Juices.

1. **T**HE gastric juice, which always exists more or less abundantly in the stomach of animals, and moistens its sides, is secreted in glands which are very perceptible in birds, but are difficult to be seen, and appear to be but very little abundant in the human species and the mammalia. This juice is likewise very difficult to be obtained pure, because it is so frequently mixed with saliva, with mucus, with bile, with the residuum of the aliments, &c.

VOL. X.

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This is the reason why many authors, without denying its existence, have at least doubted of its great influence in digestion. Ancient chemical experiments had already been made upon the gastric juice, by Wepfer, Brunner, Viridet, Floyer, Rast, as we see from the short notice published by Haller, in his *Physiology*. But these experiments were very little adapted to afford any light respecting the nature of this humour; they could only throw obscurity over its properties. Besides, it had always appeared difficult to procure a sufficient quantity of it to subject it to an exact analysis, and it is only in modern times that we have begun to find means of obtaining it pure.

2. Since 1744, Reaumur, one of the French physicians and naturalists, who best perceived the necessity of making experiments with accuracy and precision upon the living animals, first conceived and executed the project of examining the gastric juice, and determining its effect in the digestion of the aliments. He has well demonstrated that this function is not performed by pressure and trituration, but that it is principally owing to the action of this juice. Since him, Spallanzani resumed this inquiry nearly twenty years ago, and carried his experiments much farther than Reaumur had done, especially with regard to the processes for collecting the gastric juice as pure as possible, and so as to be able to subject it to some chemical experiments. He especially recalled in some measure the
the

the attention of philosophers to this matter, and it was since his inquiry that Citizens Scopoli, Monch, Brugnatelli, Carminati, Jurine, Goffe, Toggia, Vauquelin, and Macquart, undertook different researches, with the aid of which we have at present, if not a complete knowledge, at least some more positive notions concerning the subject than were formerly possessed.

3. We have no accurate knowledge respecting the true source of the gastric juice, and there does not appear to be any glandular organ destined for its secretion, at least not in the mammalia. We cannot therefore obtain this juice very pure from any reservoir in which we can be certain of finding a sufficient quantity of it; it is not possible to obtain it sufficiently pure, as Spallanzani has done, unless by causing birds to swallow sponges, having a string attached to them which issues out of the beak, and drawing them out again after having suffered them to remain some hours in the stomachs of these animals whilst fasting. That of the human species, which has been procured by means of emetics, that which has been taken from the stomachs of calves or sheep immediately after they have been killed, having been made to fast for some time before, cannot be considered as pure gastric juice, because it is mixed either with the other liquors expressed at the same time, or with some remains of the aliments. We are therefore by no means as yet entitled

to consider the analysis of the gastric juice as sufficient for animal philosophy: what has hitherto been done can only be considered as preliminary essays proper for giving an idea of its importance.

4. For a want of a series of experiments upon the nature of the pure gastric juice, we may be assisted, in commencing the study of its properties, by several other experiments, which without having a direct relation with the true chemical processes, may at least supply their place. I place under this head the observations made upon the aliments discharged, by natural or artificial vomiting, at different periods of the digestion, the numerous investigations of Reaumur and Spallanzani upon the effects produced upon different aliments, by remaining inclosed in open tubes, in the midst of the stomach, where they can only be penetrated and changed by the gastric juice; the facts observed by some authors upon the gastric juice, or at least upon a liquid of the stomach which must contain it, evacuated by the efforts of vomiting; the experiments made by several modern physicians, as well upon different substances remaining immersed in the gastric juice of birds, and of some of the mammalia, as upon the applications of this juice in several internal and external maladies. By combining the result of these different observations or experimental attempts with the portion of real chemical researches that have been commenced upon the
gastric

gastric juice by some modern chemists, we shall at least find in them several points of the chemical history of this fluid.

5. Several physiologists assert that they have found the gastric juice acid, either after it had been discharged by natural vomiting, or after the effect of an emetic, or even in the stomachs of animals opened for anatomical observations. In these cases it has several times been found sufficiently sour to redden turnsole and to effervesce with the alkaline carbonates. Some have even gone so far as to assert that the sides of the stomach were equally acid. Others have found the gastric juice at the same time bitter, acrid and acid in birds of prey; aqueous, turbid and saline in the ruminant animals. Citizen Goffe, of Geneva, observed that his own gastric juice had a well-marked acidity when he had eaten crude vegetables. Spallanzani believes that this character depends upon the nature of the aliments and does not belong to the gastric juice properly so called; for he assures us that he has never found it acid in the carnivorous, but on the contrary always so in the frugivorous animals. The acidity found in the gastric juice is owing, according to some, to an acid analogous to that of the lemon, of sorrel, or of vinegar; whilst Citizen Brugnatelli has believed it to be produced by the phosphoric acid, which Citizens Vauquelin and Macquart have actually discovered in the gastric juice of the calf, the bullock, and the sheep. To these first notions

we must subjoin what other observers have had occasion to remark upon aliments thrown up at different periods after their having been received into the stomach, which they have found more or less sour, and the numerous facts of flatulencies and eructations, which frequently give rise to a very strong and disagreeable sensation of acidity in the throat and mouth.

6. In the series of experiments made by Spallanzani upon the effects produced in the aliments by the gastric juice with different animals, experiments confirming of those of Reaumur, he has found that this juice is the principal agent in digestion, that it changes the aliments into a soft and homogeneous paste; that it softens cartilages, tendons and even bones: that it dissolves vegetable or animal substances without distinction, without appearing to have more attraction for the one than for the other, notwithstanding the nature of the animals and their kind of food, that it is one of the most powerful antiseptics, since it restores putrefied flesh introduced into the stomach, and prevents the septic alteration of substances, otherwise very susceptible of putrefaction, which are left immersed in it. It is a solvent of singular activity, without acrimony, which unites readily with all the alimentary substances. The results which I here indicate, were obtained by the professor of Pavia by causing birds and mammalia to swallow tubes of wood, open and provided with wire-work at their

their ends, in order to contain the fragments of different substances, and suffer the gastric juice to penetrate easily into them.

7. One of the most remarkable qualities of the gastric juice, consisting in its antiseptic quality, must also have most struck the attention of philosophers, and they have performed many numerous experiments upon it. After having extracted this juice from crows and sheep, either by causing them to swallow metallic balls, or by opening their stomachs and taking it immediately from them; after having found that the most putrescible animal matters, surrounded with this liquid, remained in it for several days without alteration, though the same substances, kept out of it, either alone or steeped in water, easily corrupted; Citizens Carminati, Jurine and Toggia applied this juice to the surface of fetid ulcers, and found it to prove very effectual in checking the putrid disposition of these surfaces. This experiment has been repeated by several physicians since the first trials, and most of them have confirmed the general result here indicated. However it does not appear to have been sufficiently satisfactory to the faculty, as its use has not become general during ten years since these experiments have been commenced, and the employment of the gastric juice has not been substituted instead of the external antiseptics which were known and applied long before.

8. We

8. We may conclude from the combination of these different orders of facts, that the general nature of the gastric juice is yet far from being known, according to the physiological facts ; that this juice appears to differ in the different animals and to be similar in all of them only by its softening and solvent property ; that its sensible properties appear to receive varied modifications from the aliments received into the stomach, especially when these have been used for some time, that though it is sometimes or even often acid, it is not to its peculiar nature that this character belongs, but to the admixtures of the alimentary residues, and that there is no particular acid which ought to be called gastric acid, as some chemists have believed, or at least that its existence has not been proved ; that what most essentially characterizes this living animal liquid is its two fold property of dissolving, or at least of melting or softening all the matters charged with alimentary particles, and of retarding or entirely stopping their putrid decomposition, and even of correcting this decomposition when already well marked in alimentary substances.

9. Perhaps the idea of the energy of this solvent power has been carried too far when it has been said that the hardest siliceous stones, even rock-crystal itself were blunted at their angles, deprived of their polish, and consequently dissolved by the action of the gastric juice. It is much more easy to conceive the singular observa-

observation of Hunter, who has remarked this solvent power acting upon the sides of the stomach itself, softening, macerating, dissolving them, when there are no more aliments in this viscus upon which its powers can be exerted, and this effect taking place even some hours after death. Perhaps it is in this circumstance that the sensation of hunger consists, which, when it has continued for some time, becomes a painful sensation, like that produced by an acrid or slight corrosive. Though it is difficult to raise doubts respecting experiments repeated by so many able and accurate philosophers, I have to oppose to them the experiments of Citizens Macquart and Vauquelin, of which I myself have been a witness, and which were made in my laboratory; flesh immersed in the gastric juice of the bullock, the calf and the sheep, putrefied as easily and as quickly as portions of the same flesh that had remained in contact with the air, or were macerated in water.

10. The first physiologists who employed chemical means and inductions for ascertaining the nature of the gastric juice obtained only uncertain results, and most of them of little utility. According to Reaumur, Viridet, Deidier, Peyer, Brunner, Langrith, and Collins, this juice considered as salivary, is entirely evaporable, mucous insipid or slightly saline, neither acid nor alkaline. Rast of Lyons, in experiments which he performed at the suggestion

tion of Haller, found the gastric juice in the mule and the sheep, when fattening, to be mucous viscid, frothy and liable to become fetid, not coagulable by the sulphuric and nitric acids, to turn the colour of violets green, to froth by agitation, to be entirely volatilized by fire unalterable by alcohol, and to deposit filaments by the action of a fixed alkali. Haller concluded from these experiments, which were made at his solicitation, that the gastric juice was a compound of water and of a mucilage, and that it approached to the alkaline nature. For the rest, he considered it as a mixture of saliva, of the mucus of the stomach, of the juice of the œsophagus, of the pancreatic humour, and of a kind of mucus secreted by glands. It is evident that the immortal anatomist of Helvetia had not more accurate ideas of the nature of the gastric juice than he had of most of the animal liquids. It is true, he wrote this part of his great work in 1764, at a period when the organic chemistry was still involved in the most profound darkness.

11. Mr. Scopoli has examined with a little more care and accuracy the gastric juice of the crow, which Spallanzani had sent him, requesting that he might subject it to chemical analysis. Mr. Scopoli perceived in it at first a disagreeable odour: lime and pot-ash developed ammonia from it. It turned the syrup of violets green; it produced no effervescence with the powerful acids. Exposed to a slow fire, it yielded about $\frac{1}{7}$

of a deliquescent fetid, not effervescent residuum. He extracted from it by distillation an ammoniacal water, and concrete carbonate of ammonia; it condensed in the retort into an obscure extractiform mass, not effervescent, of an empyreumatic smell, of a saline, bitter, nauseous taste, exhaling ammonia by the contact of a fixed alkali. This juice precipitated the nitrate into muriate of silver. He concluded from these experiments, that the gastric juice of the crow was a compound of water, of saponaceous and gelatinous animal matter, of muriate of ammonia and of phosphate of lime, which Mr. Scopoli calls *animal earth*. It is evident that this analysis, inserted in the work of Spallanzani upon digestion has no direct relation with the researches of this physician, and that they have afforded no light respecting the great solvent force or the antiseptic property of the gastric juice.

12. Since the experiments of Mr. Scopoli upon the gastric juice of crows, I know only Citizens Macquart and Vauquelin, who have occupied themselves with some chemical researches respecting this animal liquor. They procured from the slaughter-houses gastric juice of sheep, bullocks and calves. It is natural to suppose that in operating upon the liquor of the stomach of ruminant animals, they must have obtained results different from those of Mr. Scopoli. Accordingly they found in it phosphates and free phosphoric acid of which

which the Italian chemist makes no mention. They also separated a small quantity of albumen from it by the acids, besides which they obtained a mucous or gelatinous animal substance. None of the gastric juices which they analysed presented to them that antiseptic property of which so much has been said; all three, on the contrary, corrupted in some days time, and becoming turbid, exhaled a very fetid smell. It may be believed that, if the antiseptic property of the gastric juice be proved in the living stomach by the experiments of Spallanzani, which in fact show that animal matters do not contract a bad smell in this viscus, and that those which are introduced into it with certain signs of putrefaction are corrected by the very act of digestion, yet this antiseptic property at least loses much of its energy out of the stomach, and that the gastric juice then putrefies with more or less facility. The fetid smell which Mr. Scopoli has described in the gastric juice of the crow, which Spallanzani had given him to analyse, sufficiently indicates this property of septicity.

13. I have joined the pancreatic with the gastric juice, as well because the source and the reservoir of these two liquids are contiguous with each other, as because the history of the pancreatic juice contains nothing real, nothing sufficiently known or sufficiently important to deserve to be treated of separately. It is known that the pancreas, a gland of considerable

able magnitude, situated in the circunvolutions of the duodenum, has an excretory duct of the diameter of a writing pen, described and delineated in 1642, by Wirfungus, formed by the union of a great number of other small ducts, and which proceeds increasing in magnitude, from the left to the right, till it opens into the duodenum, after having united with the ductus choledochus within the membranes of the intestines themselves. This duct is almost always found empty in dissections. Haller has never been able to find pancreatic juice in it with the human subject, and Rast could never succeed, in the veterinary school of Lyons, at the solicitation of Haller, to find a sufficient quantity of it and separate it sufficiently from the bile, in the largest animals, for it to be subjected to experiments.

14. The desire of supporting the opinion of their perceptor, F. Sylvius, suggested to Reg. de Graaf and Schuyt the means of procuring this juice, by introducing into the pancreatic duct of dogs a phial, which they tied to it, and in which the juice collected. Though most of the animals perished under the operation, which in fact is a very difficult one, and affords no hope of success, they succeeded in it sufficiently well to ascertain that this liquor was of a whitish colour, of a slightly saline taste, and very similar to the saliva, as the structure of the pancreas and of its duct resembles that of the salivary glands and ducts.

Collins

Collins has since found the same analogy between the pancreatic and the salivary calculi. Graaf collected to the amount of 32 grammes of this juice in eight hours in a dog, and Schuyl more than 90 grammes in two hours in the same animal. The first of these anatomists, calculating according to the comparative weight of the body, has estimated that in man 288 grammes (nearly nine ounces) of pancreatic juice may be effused in 24 hours; and Haller finds this calculation too low, even according to the comparison of the salivary glands.

15. Graaf and Schuyl, at the end of the last century, asserted that the pancreatic juice, like the saliva, was acid; that it reddened the tincture of turnsole; that it coagulated milk, and that its taste was manifestly sour. It was in this manner that they supported the hypothesis of Sylvius, who maintained that this acid juice made effervescence with the bile, separated the chyle from the excrements, and being carried with the blood into the heart, acted there by irritating and distending it by means of the same effervescence. Dippel maintained the same idea concerning the pancreatic juice, and carried it so far as to pretend that the pancreas gave an acid and not an alkali in distillation. This hypothesis of Sylvius did not maintain itself long: its abuse was carried to that degree, that it was expected to indicate the cause of diseases and the indication of the remedies. Drelincourt, Pechlin, Brunner, Bohn,

Bohn, Fred. Hoffmann, and Boërhaave the successor of Sylvius, combated it with advantage; they maintained that the pancreatic juice was not acid, that it did not coagulate milk. Two witnesses of the too famous experiments of Graaf upon a sailor who had suddenly died, and in whom he said he had found the pancreatic juice acid, asserted that this juice was insipid; Deider even showed that on the contrary it turned the syrup of violets green, and as the principal hypothesis of Sylvius consisted in attributing the cause of the motion of the heart, and the true vital principle to the pancreatic liquor, Brunner contributed much to overturn it by proving that dogs from which he had either cut out the pancreas, or destroyed, or tied their pancreatic duct, lived even without any very severe or very perceptible morbid consequences.

16. The comparison and a certain analogy between the pancreatic juice, and the saliva have however been considered as sufficiently exact assertions in the schools, since the fall of the hypothesis of Sylvius, and they are generally admitted, though no positive experiments have been made upon the nature of this juice. It is believed to be formed for diluting the the cystic bile, diminishing its acrimony and its power of acting upon the intestines, favouring its mixture with the aliments, and thus retarding their descent into the intestinal canal. Hence, it is said, exist the greater degree

degree of hunger and the vomiting of bile with animals from which the pancreas has been taken out, and the size of this gland proportionate to the abundance and the acrimony of the bile. The pancreatic juice is also admitted to possess the property of diluting and dissolving the alimentary mass. Upon this principle physiologists explain the voracity of animals, in which this juice is poured out into the stomach or very near to this viscus, the largeness of the pancreas in animals that do not drink, the dryness and constriction of the belly in subjects with whom the pancreatic duct is compressed, as in the dogs from which Brunner cut out the pancreas. For the rest, a new and important analysis which still remains to be made, is that of this liquid hitherto so little known, and nevertheless so interesting to be known for animal physiology and medicine.

ARTICLE XXI.

Of the Bile.

SECTION I.

Formation and Secretion of the Bile.

1. THE bile is one of the animal humours which require the most profound study, not only on account of its importance in the animal economy, the part which it acts in digestion, the extensive and remarkable apparatus which nature has appropriated to its formation and its secretion, but likewise of the numerous alterations of which it is susceptible, the knowledge of which is of so great importance to physicians. Neither is there any matter upon which more has been written; and nevertheless it was not till some years after the middle of the eighteenth century, that we began to acquire accurate notions respecting its nature and composition, as I shall soon make appear. But what substance amongst all that the animal body presents requires more to be well known? Continually prepared by a viscus of considerable volume and weight, the extent of its secreting organs is alone sufficient to show that it is destined for uses of a very high order in the

support of life. We find the liver in almost all animals, down to the insects and worms, in which indeed it presents a structure very different from that observed in the mammalia, the birds, and the fishes, by the numerous, insulated, and floating vascular filaments which constitute it in these two classes of animals. It constantly occupies a large space in their bodies, and it constitutes a well determined system of organs and functions destined to exert a great influence upon the animal machine.

2. The liver, a very large viscus in man and in the mammalia, placed in one of the sides of the abdominal cavity, of a deep red colour, which the 'ancients considered as an entirely sanguineous organ,' destined for the formation of the blood, receives a large quantity of a particular blood different from that which exists in the other regions of the body, and is transmitted to it by a vascular system equally distinct from all the other apparatuses of vessels. It is from the surface of the intestines, from the epiploon, the mesentery and mesocolon, the spleen and the stomach, that the blood destined for the liver derives its origin: the veins, returning from all these regions, unite into a large arteriform vessel, or one that performs the function of an artery, which is called the vena port. The greatest anatomists and physiologists, Malpighi, Glisson, Bianchi, Fanton, Senac, who have long occupied themselves with researches concerning the structure of
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the liver and of the whole hepatic system, have admitted a particular character in the blood destined for the secretion of the bile. After all the ridiculous opinions that have been advanced, from the times of antiquity down to the present age, it has been generally agreed that this viscus is destined to give to the blood, which penetrates its texture in abundance, a quality particularly relative to the formation of the bile. It results from all the facts that have hitherto been collected upon this subject, that the blood of the vena port, being more black, and slower in its motion, appears to be impregnated with fatty humour, with vapour from the excrements, even with a bitter quality, and disposed not only to the separation of an oily matter, but also to that of a liquor more inclined than any other to alkalescence; and though Haller has justly observed that there was as yet no positive experiment for proving this particular character of the blood of the vena port, he has however not been able to disavow that anatomical appearances and the combination of all the physiological circumstances rendered this view of the particular nature of the hepatic blood almost as probable as experiment could do.

3. The vascular extremities of the vena port appear to terminate partly in the ramifications of the vena cava, partly in biliary pores, the union of which gives rise to the hepatic duct. From this duct the bile flows in man, and in

especially in diseases, from the consistence of a thick oil, or a pitchy and glutinous matter, to a concrete state of more or less solidity.

Its density is in general, greater than that of water, though it is also susceptible of several variations. Wischer has found its weight compared with that of water as 102 to 100, or as 810 : 795. Lamure indicates the relation between these two liquids as 58 to 37. It has also been indicated as lighter than the milk and the blood. According to Silberling, who has written a particular dissertation upon the specific weight of the animal humours, the weight of the bile is to that of the milk as 2004 to 2086 and to that of the blood as 395 to 406. Hamburger gives this last proportion as 2006 : 2072; Jurin as 100 : 102. Muschenbroeck indicates the proportion of the weight of the bile to that of water as 1,0246 : 1,0000. Bianchi Hartman, and Payen however say that the bile is heavier than the blood. These differences announce a remarkable variation, which depends upon a multitude of circumstances relative to the health and sickness of the individual.

6. The colour of the bile is very frequently green or always mixed with this tinge : it is constantly green in birds, quadrupeds, the oviparous animals, and the fishes. It has been found blue in the rattle-snake. It is of a greenish yellow colour in most of the mammalia, and in man. The yellow is so essential to its nature, that it tinges with this cast both the vessels in which it
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is contained, and the vicinity of the gall-bladder through the pores of which it transpires, as also the parts below the epidermis when it is conveyed into and detained in the vessels spread out under this integument; it acquires a deeper colour the longer it has remained in its receptacles. Its yellow colour always accompanies its thick state and its fluidity; its thinness is constantly marked by the green colour: however, this last colour is generally produced in the fœtus before the bitter taste. For the rest, nothing appears to be more variable than the colour of the bile. Madder, taken internally, has been observed to give a red cast to the bile at the same time that it gave this colour to the bones. This liquid is so intensely bitter, that six drops of bile communicate an intolerably bitter taste to 33 grammes of pure water. This bitterness is general in all kinds of bile; it is even combined with an harshness, an acrid property, which goes as far as the virous nature in some of the amphibia. When it is aqueous it is insipid; when it is acrid it is at the same time thick, since these states constantly correspond in the different circumstances.

7. Fresh bile diffuses a very particular faint smell, which Ramsay has described as aromatic, but which is sometimes fetid. I shall soon speak of the causes and of the circumstances which sometimes produces in the bile a very marked smell of musk. It froths much by agitation. It is not easy to determine the quantity of it which

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is formed in man during a given time. Some physiologists have occupied themselves with this subject : and by taking the mean term of their calculations, we may approach pretty near to the truth. Cujet. Tacconus collected 130 grammes (about 4 ounces) of bile at a single time ; by a wound that penetrated into the gall-bladder. Bianchi has estimated that 65 grammes (about 2 ounces) flow in 24 hours from the gall-bladder. This quantity appears much too small to Haller, who estimates with Valcarenghi that nearly 780 grammes (24 ounces) of it are effused in 24 hours, and who thinks that of these 780 grammes 130 collect in the gall-bladder, where they are detained for some time, and 650 flow gradually into the intestine. Some anatomists however believe that the whole of the bile passes out of the liver into the gall-bladder, and that it does not flow into the duodenum, which is closed and folded together except during the time of digestion. It is also here to be remarked that in the vertical position of man, the bile does not flow out of the vesicle into the intestine except when the full stomach raises itself in such a manner as to place its bottom higher than the extremity of the ductus choledochus, and that the horizontal situation upon the left side is the circumstance most favourable to this discharge.

8. The bile has been examined with more attention and has been sooner pretty well known than most of the other animal liquids, either because

because the importance of this examination has been early perceived, or because its analysis, which in general is more easy and simple, gave to the first men of learning who occupied themselves with it pretty satisfactory results. Boerhaave and Bianchi have made it the subject of several experiments, without however determining its nature with sufficient exactness. We are even astonished that the very clear sighted eye of the celebrated professor of Leyden should have been so much deceived, as to represent the bile as the most putrescible of the animal fluids; an error which has prevailed more than sixty years in medicine, and which has formed the base of a great number of hypothetical theories concerning diseases and their treatment.

Verheyen has analysed the bile much better than the preceding, and has only been surpassed by the modern chemists.

Fred. Hoffmann, Drelincourt, Hartmann, Barchusen, Wischer and many other physicians have given us useful facts respecting the properties of this liquor. Schroeder has examined a considerable number of mixtures of bile with different, especially animal, liquors. Mather has especially directed his attention to the animal mucilage of the bile, and believed that all its effects were especially owing to it.

Gaubius, in his chymical lectures, treated the analysis of the bile much in detail, and a great number of his pupils have availed themselves of his labours, the whole merit of which Haller,
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who quotes him often, has justly attributed to him.

Cadet, of the Academy of Sciences of Paris gave, in 1767, a good Memoir upon the bile; and he began to diffuse more accurate ideas than those which had been advanced before him respecting the saponaceous composition of this liquor, and the soda which is contained in it.

Poullétier de la Salle has published, in Madame Darconville's treatise on putrefaction, some interesting experiments on the human bile.

Van Bochaute, Professor at Louvain, wrote, in 1778, a Latin Dissertation, containing important observations respecting the nature of this liquor, the oily matter, and the means of separating all the materials which constitute it.

Lastly, I have added several new facts respecting the analysis of the bile, its oily substance, its alterations, its precipitation by different re-agents, the nature of the parenchyma of the bile, the secretion which it performs, as well as respecting the nature of the blood that flows into it. The results of all these labours arranged in the order which I have adopted for the exposition of all the animal substances, will form the subject of the present article.

SECTION. III.

SECTION III.

Of the Chemical Properties of the Bile.

9. WHEN the bile is exposed to a mild heat, it becomes thickened, and loses the greater part of its weight, being reduced to one-eighth. The water which exhales from it diffuses in the laboratory a faint, disagreeable smell, which cannot be described, but which however is very distinguishable. We thus obtain a solid mass, of a dark-brown colour, of a bitter and at the same time sweetish taste, which is softened by the warmth of the hands, is ductile and pitchy, attracts the moisture of the atmosphere, dissolves in water, leaving however a small quantity of residuum, producing a slight effervescence with the acids, and acquiring, when kept for some time, a very perceptible smell of musk or amber-grease: this is what is called the *sapa*, or the *extract of the bile*. When this operation is performed in close vessels, and by the mere heat of the water-bath we obtain nearly seven-ninths of the weight of the bile of a very clear water, having a faint smell, which presents nothing by the re-agents, unless the distillation be carried too far, or the bile be altered and corrupted. In the latter case, the aqueous product has frequently a pretty strong
smell

smell of musk, and becomes turbid as it cools. The residuum of this distillation is extract of bile, as in the evaporation by open fire.

10. The inspissated bile, or the extract of bile, when heated in a retort, is decomposed with particular phenomena. When the fire is applied with caution and in a successive manner, we first obtain water a little turbid, already of a fetid smell, precipitating the metallic salts, and almost always containing sulphurated hydrogen. The bile afterwards swells considerably, increases in volume so as to fill almost the whole of the retort: the liquid which then passes is brown and very fetid; it contains carbonate and zoonate of ammonia. It is soon succeeded by an oil, at first thin and light, afterwards brown, thick, and empyreumatic, and of an intolerably fetid odour; at the same time that solid and crystallized carbonate of ammonia attaches itself to the sides of the receiver, and there passes with rapidity and in abundance an elastic fluid, consisting of a mixture of carbonic acid gas, carbonated and sulphurated hydrogen gas, frequently containing a small quantity of oil in the state of vapour. Amongst these products it is observed, that the carbonate of ammonia does not amount to an eighth of the quantity which is obtained from the blood and the bones of animals; and this observation, which has escaped neither Verheyen nor Van Bochaute, has induced the latter to conclude that the bile is much less animalized than many other
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other animal substances. There remains a very black, spongy and swelled coal, which burns easily, from which Verheyen extracted fixed alkali, of the nature of which he was then ignorant, though he obtained it without incinerating this coal. This coal, after it has been exposed for some days' to the air, presents an efflorescence of carbonate of soda. When it is well incinerated, it preserves a deep grey colour; there is separated from it, with the aid of cold water, almost half its weight of carbonate of soda, a little muriate of soda, phosphate of the same base, phosphate of lime, and some traces of iron. It is to be observed, that if the retort has not been sufficiently heated in this operation, and if the bile has not been well reduced to coal, we have in the retort, instead of a real coal, a black mass resembling a bitumen, luminous and brittle, liquifiable by a strong heat, and which keeps very dry with the contact of the air.

11. The bile has always been considered amongst physicians, and especially since Boerhaave, as one of the most putrescible animal liquids that are known; and it is considered in this light because, in fact, when kept in air, the temperature of which exceeds 15 degrees, it pretty quickly diffuses a disagreeable smell, which soon announces a rapid putrefaction. However, Van Bochaute has given in his Dissertation a contradictory experiment; and he has rather strongly combated the opinion of Boerhaave

Boerhaave respecting this putrescible property of the bile. Human bile, he says, which was very thick, and of a dark green colour, mixed with a small quantity of distilled water, and placed in a bottle half filled and well closed, kept for six intire months without exhibiting any signs even of incipient putrescence; but on the contrary it diffused a manifestly vinous odour; which led him to think that it contained a saccharine matter in quantity sufficient even for carrying the mass into the vinous fermentation. But without denying the truth of this experiment, it is too well known to anatomists, to physicians, and even to fullers, who employ large quantities of bullock's bile or gall under the name of bitter, for taking spots out of cloth, that this liquor putrefies readily in the hot air for it to be possible to doubt of this property. We may only conclude, that though the putrefactive movement shows itself easily in this liquor, it advances but very slowly and with much difficulty towards its total decomposition, on account even of the bitter property of this animal liquid, and the saponaceous nature of a part of its substance, of which I am about to speak. When bile that has already become a little fetid is boiled for some instants, it assumes a fine green colour, and afterwards keeps for a long time without alteration.

12. Thick and ropy bile, poured into water, first passes through it and collects at the bottom of this liquid as being more heavy, on account
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of its tenacity. At the end of some hours, the mixture of the two liquors is gradually effected. By agitation this mixture is effected immediately; the bile loses its viscosity, or ropy property; it partakes of the liquidity of water; it gives it a yellow colour, verging upon brown, or a mere golden yellow when the water is very abundant. When the bile is green, this cast does not remain in the water, or it disappears very quickly in the air, and passes to the yellow colour. When we heat bile diluted with its own weight of water, we observe no coagulation of the albuminous matter which it contains, because it is held in perfect solution by the alkaline soap of which I shall soon speak. Van Bochaute, who well knew this phenomenon, saw and announced that white of egg, beat up and added to the bile, does not coagulate in this liquor, even though boiling, and that its saponaceous quality, by dissolving and retaining it united with the water, prevented its concretion by the fire. The bile diluted with a small quantity of water turns the syrup of violets green, and also paper tinged with mallows, renders violet that which has been coloured with cucurma. It is difficult to conceive how Boerhaave, Haller, Marherr, and several other physiologists, have mistaken and denied the alkaline nature of the bile, which shows itself, as we shall see by a great number of indubitable facts.

13. All the acids poured upon the bile decompose it, and produce an abundant precipitation in it. If we put into the bile only a few drops of an acid, the precipitate forms at first an opaque cloud which assumes the appearance of froth, in which many small bubbles of gas are perceived. In all these decompositions, the precipitate acquires a green colour, especially by the muriatic acid. A part of this precipitate remains suspended and even dissolved in the fluid when it is much agitated, or when these matters are left for some time in contact. The liquor, when filtrated, leaves upon the filtre a coagulated albuminous animal matter: when evaporated, this liquor deposits flakes of a deep green colour, similar to pitch, which soften and appear tenacious and gluey under the fingers, and when thrown upon ignited coals, swell and inflame readily, burning after the manner of a resin. After the separation of this resiniform matter, the liquor affords by evaporation a salt with soda for its base, differing according to the species of acid that has been employed. It is in this manner that the chemists, for forty years past, have proved the presence of soda in the bile, and its combination with an oil in the saponaceous state.

14. The chemists who have examined the action of the acids upon the bile in detail, have remarked that at least three different crystalline matters were obtained from the filtrated liquors:
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that which the acid employed must form with the soda, and they have all recognized the sulphate, the nitrate, the muriate or the acetate of soda in such a manner as not to leave the smallest doubt: a second salt, constantly obtained in their experiments, has been described as small needles, and taken for a calcareous salt formed also by the acid employed and lime, the presence of which they have thus admitted in the bile; and lastly, a third crystalline matter in trapezoids, of a weak and sweetish taste, which Cadet has considered as a matter analogous to the sugar of milk, which Van Bochaute has afterwards sought by many different processes, and the presence of which is not yet accurately proved, though traces of it have been rather decidedly found in the sweetish taste of the extract of the bile, in its property of passing into a kind of vinous fermentation described by Van Bochaute, and in several other facts that shall be successively indicated.

15. We see at least, from these details, that the acids act in three ways at once upon the bile: they coagulate its albumen which is precipitated in masses; they separate its oily matter by seizing the soda which held it in saponaceous solution; they decompose the phosphoric salts, especially the calcareous, and that with soda for its base, when the acids employed are more powerful than the phosphoric: for I have already shown that these phosphates are contained in the bile. It is therefore not difficult to con-

ceive why chemists have so greatly multiplied their experiments upon the treatment of the bile by the acids, and how they have availed themselves of this treatment for determining its properties as well as its composition.

There are some particular facts to be known concerning the species of acids with respect to their manner of acting upon the bile. The concentrated sulphuric acid coagulates it in dense flakes, and gives it a deep colour; the weak sulphuric acid renders it intensely green. The nitric, after having precipitated it green in the cold, assumes a golden-yellow colour with it when it is heated for a sufficient length of time; it converts part of it into oxalic and into Prussic acid, and alters its oily matter. The muriatic acid, which at first precipitates it of a green colour, afterwards assumes a violet cast, especially by the action of heat. The oxygenated muriatic acid whitens it and renders it turbid like milk; it changes the nature of the albuminous principle, of the oily substance and of the colouring matter of the bile: it precipitates from it filaments similar to those which frequently constitute the biliary calculi; its action still deserves to be examined anew, and attentively studied by chemists.

16. The precipitate formed in the bile by the acids is composed of two principal matters: the one, which is manifestly an animal substance; the other is a sort of oily body, upon the nature of which chemists are not yet agreed. These two matters

matters are separated by means of alcohol, which dissolves the latter without touching the first. This alcohol acquires a brown-yellow colour in proportion as it dissolves the oily substance. If we let it evaporate spontaneously in the air, there separate from it at its surface some drops of an oily liquor, which has the smell and the acrid bitterness of myrrh, with which several chemists have compared it: and there is deposited from it a tenaceous ropy matter, of a deep brown colour, which does not inflame upon ignited coals, which is still soluble in alcohol, but insoluble in water. The solution of this substance in alcohol is abundantly precipitated by water, and the collected deposition softens over a gentle fire. All these properties have induced Van Bochaute to consider it as a resin, which he has compared with that of the jalap, and which he believes to be almost of a vegetable nature. But the resins properly so called are not soluble in fixed alkali, and do not form real soap: it is therefore a matter not really resinous, but oily of a particular kind, which seems to approach, as I shall soon show more in detail, to what I call adipocire.

17. When the precipitate of the bile has been treated and discoloured by alcohol, till this no longer takes up any thing from it, there remains a white or grey matter, not fusible in the fire, insipid, or scarcely at all bitter, insoluble in cold or hot water, soluble in the leys of caustic fixed alkalis, which burns

upon the coals with a smell of horn, and affords, in its analysis by the retort and by the different re-agents, altogether the same products as this last-mentioned substance, more especially an abundant quantity of carbonate of ammonia. Its coal contains a remarkable quantity of phosphate of lime; it is therefore a well characterized animal substance. Some modern chemists have believed it to be composed of two substances, of gelatinous mucilage, or gelatin and of albuminous matter. But this opinion is not supported by experience; for it has not been proved that water forms jelly with this portion of the precipitate of the bile; and it ought manifestly to form it if it contained the gelatinous substance. On the contrary, Verheyen, Cadet, Van Bochaute, and Marherr, have all compared it with horn, both in its combustion and in its distillation, which announces its analogy with the albuminous substance.

18. The alkalis do not exert so powerful an action upon the bile as the acids. It has been stated that they deprive it of its bitterness. They do not coagulate it; but they render it sensibly more fluid; and they alter its colouring matter but very little. The solutions of barites, of strontian and of lime, form in it at first a light precipitate which is an insoluble earthy phosphate; a larger portion of these solutions separates from it the oily matter, with which the earths form an insoluble soap. The fixed alkalis well concentrated disengage a very perceptible ammoniacal

ammoniacal smell, and thus demonstrate the presence of an ammoniacal salt in it, which probably is a phosphate. The salts have but very little effect upon the bile, if we except the soluble earthy salts, all which precipitate it, and form earthy soaps, by decomposing the soap of soda which it contains. The same is the case with the metallic salts: most of them decompose the bile, and are decomposed by it; they form precipitates composed of coagulated albumen, of metallic soap, of metallic muriates and phosphates. Accordingly, we see that these salts, administered in medicine, especially in the small doses in which they are given, undergo in the first intestines, and sometimes even in the stomach, a decomposition which renders their action either feeble or different from what medical theory has hitherto represented it.

19. Amongst the vegetable matters, it unites with all that are soluble in water: it has been quoted as acting particularly upon the oily substances; and hitherto all the chemists have so positively attributed to it the property of dissolving the fixed oils especially, that it is even on account of this property that it has been considered as a soap; it is to this that they ascribed its action in digestion as well as that which it exerts in the fuller's art. Van Bochaute had even advanced, with respect to the latter use, that the bile was the most soluble soap, which took out spots of oil and grease from cloth

cloth with more energy than any other known soap. However, Professor Jos. Ja. Plenck, in his Hygrology of the Human Body, published at Louvain, in 1797, in which he has employed most of the new facts for which the science is indebted to the French chemists, without once quoting their authors, says positively that the bile contracts no union either with the fixed or the volatile oils; that it does not dissolve them, nor render them miscible with water; that, as a compound of resin and alkali, the latter in too small quantity, it is not a soap, nor soluble in water, like a soap. He adds, in order to explain its action upon linen and cloth impregnated with oil, that it has more affinity for the texture of these stuffs than oil has, and that it does nothing more than take their place, by reason of the form of its particles. It is true, this author does not quote any particular experiment, neither does he indicate the source from whence he has derived this new result concerning the nature of the bile; undoubtedly on account of the brevity and the aphoristic form which he wished to give to his work. I have examined, according to this assertion, the action of the bile upon the oils; and have found that it dissolves in a very decided manner these liquids, with which it forms kinds of emulsions, and that it constantly renders them easily miscible with water. Consequently, the assertion of Mr. Plenck, in this respect, is erroneous.

20. Alcohol poured upon the bile produces in it a speedy coagulation, and separates from it flakes of slightly-coloured albuminous matter; it afterwards holds in solution the biliary soap and its colouring matter. Applied to the extract of bile, or to the bile inspissated by the action of the fire, alcohol dissolves its soapy part and the colouring substance, but does not attack the animal albuminous part. Ether separates but very little matter from it. These two solvents having been employed with much care by Van Bochaute, and having afforded him some remarkable results, I shall here quote the principal experiments, as they may be particularly useful to those chemists who may undertake new inquiries relative to this animal liquor;—inquiries called for by the national institute of France, in the question which they have proposed concerning the nature of the bile, and the function of the liver.

Van Bochaute having evaporated to dryness bile that had first been combined with an equal quantity of water, and which had not been coagulated by ebullition, treated this extract by hot alcohol till this liquor ceased to become coloured, and left only the animal substance. He obtained a tincture of a brown-yellow colour, which afforded, by evaporation, an abundant quantity of matter transparent like gum, of a sweet and honey-like taste, mixed at last with a degree of bitterness, soluble in water, which kept more than eighteen months without

alteration, and which he has proposed as a much better remedy than the simple extract of the bile. He considered this alcoholic extract as the biliary soap mixed with saccharine matter, and well separated from animal substance, which he calls *glutinous*, though it is very manifestly our albuminous matter, as the facts hitherto quoted evidently prove.

21. Van Bochaute has made several remarkable experiments upon the distillation of this alcoholic extract of bile. He obtained from it the same products as from a gum-resin; its coal contained a notable quantity of soda. Its solution in water, which was very transparent, not milky, was decomposed by the acids, and gave a precipitate which he calls *resinous, fat, pitchy*, which adhered to the fingers like turpentine, was intirely soluble in alcohol, to which it gave a brown-yellow tinge, and was separated from it by water, like the resin of jalap. This alcoholic solution of what he calls the *resin of the bile*, a resin precipitated, as we see, from the aqueous solution of the alcoholic extract of this humour, exposed to the air in a vessel covered with paper, presented to him after some days, and after the reduction of the liquor to a third of its original volume, a supernatant oil, transparent, of a gold-yellow colour, and of a bitter smell and taste, resembling those of myrrh. At the bottom of the liquor a resin was precipitated, thick, tenacious, less bitter and less odorous than the oil,

oil. From these experiments he concludes, that the oily matter combined with the soda in the bile, is a true resin, analogous to the vegetable resin, combined with an oily, aromatic, and bitter principle, similar to that of myrrh, and that these two bodies intimately united are, like the aromatic vegetable resins, the product of a thickened volatile oil. We shall soon see that this inference is not accurate in the comparison which it establishes; but that the mode and the phenomena of this experiment are nevertheless remarkable, and deserving of all the attention of the chemists.

22. The action of ether upon the extract of bile, presented to the author experiments no less interesting; and though he has not followed it so far as it requires, and as he had promised, his results are nevertheless worthy of a place in the chemical history of this animal humour. Van Bochaute, not satisfied with the first experiments of Cadet, upon the extraction of the sugar of milk from the bile, by the evaporation of the mixtures of this liquor with the acids, (experiments which, being founded merely upon the trapezoidal form, and the sweet or insipid taste of those crystals, left much doubt in his mind) tried particularly the action of ether, with the view of separating this particular matter of the bile, announced already with sufficient certainty by the sweet or even honey-like taste of the alcoholic extract of this liquor, and by the signs of vinous fermentation which he had observed

observed in it. For this purpose, he put dry extract of bile into very pure and highly rectified ether : he left this mixture in a well-closed vessel, which he frequently agitated during fourteen days. At this period the liquor was scarcely coloured : a portion being decanted, and left to spontaneous evaporation in an open vessel, presented to him on the following day an aqueous liquid of an etherated odour, upon which some drops of oil floated ; this oil, collected upon paper, had a bitter taste like myrrh, and the resinous consistence ; the liquor beneath was sweet and slightly saccharine. The author who had much confidence in this experiment, considered it as a proof and a product of the decomposition of the biliary soap ; he thought that the ether favoured and effected the separation of its oleo-resinous part ; and that by accomplishing this complete separation, by means of a series of similar experiments, he should succeed in obtaining the saccharine matter insulated, or mixed only with soda, from which he should easily be able to separate it. If he should not thus obtain the sugar of the bile sufficiently pure and well separated, he hoped to succeed by recommencing and following up this experiment repeated upon the alcoholic extract ; for that of which I have just given an account, was made upon the simple extract, or the intire bile, inspissated by the fire. Van Bochaute intended to give the results of this experiment, as soon as his avocations

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should

should have permitted him to follow it up with the requisite attention and leisure ; but he has given nothing since, for he was snatched away by death from chemistry and medicine before he could put the finishing hand to this interesting research.

23. The action of the bile upon the different animal liquors and substances has not yet been examined, though this examination might and must throw the greatest light upon the phenomena of the animal economy. Hitherto, only its mixture, its easy union, and its analogy with fat, have been spoken of ; but it is chiefly by vague views of the history of diseases, and without direct experiments, that this object has been treated, as we may see in a Memoir of Lorry, inserted among those of the Society of Medicine. Some have pretended that the bile coagulated milk ; others have denied this property. Schroeder, Professor at Gottingen, employed this coagulation of milk by the bile, as an argument against the saponaceous quality of the latter ; and Marherr has since renewed it in order to support the same opinion, and to prove that the action of the bile depended more upon its mucous nature, than upon its saponaceous quality. There is reason to believe, that it was upon the authority these two physicians that Plenck denied the biliary soap, as I have already mentioned, No. 19. Some indications collected from the experiments of Van Bochaute seem to announce that the bile retards or pre-
vents,

vents, or at least diminishes the coagulability of the albuminous substance. The effects of the bile upon the blood, the saliva, the gastric juice, the pancreatic juice, &c. are altogether unknown. These hints show how interesting the researches concerning the reciprocal action of the bile, and of the different animal matters will be, and how much this kind of experiments ought to be insisted upon by those who, at present, intend to treat the grand question of the analysis, and the uses of the hepatic system, proposed to the learned world by the National Institute of France.

24. All the known facts relative to the chemical properties and the analysis of the bile, which I have collected in this article, show that this liquid is of a very compound nature, and that it especially differs from most of the other animal substances that have hitherto been examined. It contains, as has either been proved by the facts enunciated, or indicated according to experiments more or less advanced.

A. A large quantity of water.

B. Soda.

C. An oily matter united with the latter in the saponaceous state.

D. A colouring matter combined with the preceding kind of soap.

E. A bitter and odorous oily substance.

F. A coagulable animal substance.

G. A kind of saccharine substance analogous to the sugar of milk.

H. Salts

H. Salts of several kinds.

I. Lastly, oxide of iron.

We must re-consider each of these principles in particular, and inquire how they have been found or announced in the bile, determine their state, their particular or specific nature, the mode of their combination, and their influence upon the properties of the biliary-liquor, in order to arrive at the determination of its uses in the animal economy.

SECTION. IV.

Of the different Materials of the Bile separately considered.

25. WATER is certainly the most abundant material of the bile; it is the vehicle and common solvent of all the principles that constitute it; it is that to which they owe their liquidity. Its proportion varies much, according to the different states of consistence which this humour affects. It is separated or driven off by the action of fire, and especially by distillation. On the water-bath it carries with it some light materials of this substance, which give it a faintish easily recognizable odour, and sometimes a smell of musk: the latter generally takes place only when the bile that is distilled has already been previously corrupted. The first frequently

frequently passes into the aromatic state of the second, after some time, and by a kind of fermentation. No chemist doubts either the presence or the abundance of water in the bile. It is remarkable, that it is absolutely impossible to extract it in a pure state; and that, in its separation by the fire, we only obtain it united with a biliary principle which gives it odour, and which is alterable. This principle is frequently sufficient to precipitate the acetite of lead in a white state. It would be of great importance to know whether this water exists ready formed in the blood, and be only separated from it in the liver, or whether it be not in this viscus itself that it is formed at the expense of the blood; which would explain the origin of the oily matter which is so abundant in the bile, according to the much more hydrogenated state of the blood.

26. *B.* The presence of soda is as satisfactorily proved in the bile as that of water. This alkali manifestly exists in it in the caustic state; and it is on this account that, fifty, and even thirty years ago, the alkaline nature of this humour was denied, because it did not effervesce with the acids; an indication of the presence of the alkalis, which was then admitted only because neither the carbonic acid nor the carbonates were known. Though the soda is in the saponaceous state in the bile, the acids which separate it from its oil, show that this alkali is contained in it in a much less considerable quantity

quantity than it should seem it ought to exist in it, in order to constitute a true and perfect soap. It is this soda which, remaining in the coal of the bile after the distillation of that liquor, gives it the property of immediately turning the syrup of violets green, and effloresces on the surface of the coal by long exposure to the air. The source of the soda of the bile is easily found in the alkaline nature of the serum of the blood: it easily separates from this liquid, in which it is almost insulated, on account of its weak adhesion with the kind of oil which is found developed in the tubes of the liver. Its proportion has not been determined, and it is one of the most essential of the points which ought hereafter to engage the attention of the chemists who devote themselves to the cultivation of animal chemistry.

27. *C.* The oily matter, combined with soda, is one of the most extraordinary principles of the bile. Its nature was not explained in chemistry till a considerable time after both its existence and its saponaceous form had been discovered. Van Bochaute, who first occupied himself with it in particular, has compared it to the resins, and even thought that it approached the nature of the vegetables: he founded this opinion upon the circumstance that this oily body, separated by the acids, taken up afterwards by alcohol and obtained from this liquid by evaporation, assumes a pitchy consistence, a transparent and dry state, is constantly soluble in

in alcohol, and is precipitated from it in small white drops, which remain long suspended in the liquor, and which may be rendered soft and ductile by the action of heat. Van Bochaute thought that this resinous matter might proceed from the red globules of the blood, in which Gaubius had already remarked a disposition to become resinous. The professor of Louvain adopted with respect to this subject the theory of Roux, Professor of Chemistry at the School of Medicine at Paris, who considered the bile as the natural evacuant of the colouring part of the blood. But these ideas, which are still more vague than ingenious, must give way to new researches and new experiments. In order to show their utility, and that these researches may be commenced under new auspices, I shall here quote the result of some experiments which I instituted in 1790 upon the oily matter of the bile, and which show the existence of something very different from a resin.

28. *D.* The oxygenated muriatic acid, received in the state of gas into bile, diluted with a little water, quickly destroys its colour, and coagulates the albumen, which is deposited in white flakes: its soap remains in solution without either colour or smell, but retaining its bitter taste. A larger proportion of this acid re-acts again upon this soap, and separates from it the oily matter, white, and in a concrete form. Any acid poured upon the bile already discoloured by the oxygenated muriatic acid, immediately

immediately produces in it a white concrete precipitate of the consistence of fat, which dissolves in hot water, in cold alcohol, and causes the latter to pass into the state of ether by the action of heat. This adipo-alcoholic solution, thickened to the consistence of a syrup in the air, combines with water without being precipitated : an acid decomposes it. The white concrete matter, seemingly adipocirous and not resinous, precipitated from the bile by the oxygenated muriatic acid, was first taken for the foliated substance contained in the biliary calculi, of which I shall speak in the next article ; but it differs from it by its greater softness, by its fusibility which takes place at 32 degrees of Reaumur, by its greater solubility in alcohol, and by its solubility in hot water. These experiments ought to be pursued with assiduity : it would be necessary especially to inquire whether this white precipitate of the bile by the oxygenated muriatic acid be not the biliary soap, still alkaline on account of its attraction for water ; and this is the more essential as we should not forget to remark, with regard to the fatty and colouring matter precipitated from the animal liquor by the acids, that when we attempt to wash it with water after its precipitation, this liquid carries off a considerable part of it, which it dissolves as if it were still a soap, and that the water of lixiviation is precipitated again by the addition of an acid. I have also remarked that the acid liquor, which

has always a green and sometimes a very brilliant colour, is precipitated by evaporating a portion of colouring matter, of a green cast and a pitchy consistence. Thus the oily substance of the bile is of a very singular nature, and of a very particular kind ; it is neither fat, nor resin, nor adipocire, properly so called. Its character, as intermediate between these three bodies, seems to consist in imitating all three, or differing from each, accordingly as it is treated by different processes. The true mode of its difference, depending on its intimate nature and the proportion of its principles, is not yet known, because the analysis of the fatty substances is not yet sufficiently advanced ; and it must be the work of future investigations to determine the simple ideas which exist relative to this subject, especially by ascertaining its relations with the abdominal fat from which it manifestly derives its origin.

29. *D.* The same may undoubtedly be said also of the colouring matter of the bile, which we have not yet been able to obtain separate from the fatty substance, and which adheres intimately with it, so much so indeed, that it has been very naturally confounded with it, and considered merely as a characteristic attribute of the biliary oil. Thus Van Bochaute, notwithstanding all the ingenuity with which he has conducted his experiments, destined particularly for insulating the different constituent matters of the bile by analysis, when he presents, as the
general

general result of his inquiry, this humour as a compound of much water, of albuminous mucus, partly insulated, partly united with an animal gluten, of a soap formed of resin and soda, of much saccharine mucous matter, and of a particular aroma or *spiritus rector*, does not mention the colouring matter amongst the principles which he admits in the bile. Though analysis has not yet decided upon this important point, the colour of the bile, whether considered as a particular matter, or as a characteristic property of its particular oil, appears to be, according to the experiments already described, very much disposed to the green or brown-yellow cast, very much subject to variation, capable of being made to disappear by the action of the oxygenated muriatic acid, and consequently not proceeding from iron as some chemists had thought.

30. E. I speak here of the bitter and odorous substance extracted from the bile by several chemists, and described especially by Van Bochaute, only in order to discuss the question relative to its existence or its accidental formation, perhaps owing to the experiments themselves, by which it has been obtained. It appears that the latter opinion was adopted by Van Bochaute himself; for in his conclusions upon the composition of the bile, and in his enunciation of its principles, he has not comprehended this species of oil: and in fact it was seen only in the form of some drops that swim upon the

alcoholic and etherated solution of what he calls the *resin of the bile*, or of its *soap*; there were separated from it merely some transparent drops which he could collect only upon paper; he considered them himself as a product of the decomposition of the biliary resin, as he hoped thereby to separate and to obtain in sufficient purity the saccharine mucous substance when he should have decomposed it completely. This oil, to which the same author appeared especially to ascribe the smell of musk or of myrrh which the bile acquires, particularly at the moment when the oily substance is disengaged from it, is therefore a modification of its oily matter, one of the states which it assumes in the alterations which art gives to it; perhaps even its form of transparent, volatile and odorous oily drops depends upon its union with a little of the alcohol or ether required for its extraction. It ought therefore to be considered only as one of the properties of the biliary oil, and not as one of the principles of the bile: it has never been found in it ready formed.

31. *F.* The coagulable animal matter of the bile was not distinguished in the first periods of its analysis. Cadet, who occupied himself only with the saponaceous nature of this fluid, and the saccharine substance which it appeared to him to contain, has said nothing concerning this matter. Van Bochaute has paid much attention to it; but he has not
well

well determined its nature ; he has particularly mentioned, as well as Verheyne, its property of burning with a smell of horn. He has described the means of extracting it from the precipitate of the bile by the acids, by carrying off its oily matter by means of alcohol : he has remarked the property of not coagulating by ebullition, which is communicated to the biliary soap when water is added to it ; but he had not an accurate idea of its characters, and he has described it as a kind of animal mucilage, partly insulated, and partly united with gluten, though less than in the serum of the blood. Hence it is evident that he believed the animal matter contained in the bile to be of two kinds ; the one albuminous and coagulable by the acids ; the other gelatinous. I have not had occasion to recognize these two substances in the bile. If they both exist in it at the same time, which is not improbable, because this mixture takes place in several animal liquors, the action of the acids upon the bile ought to separate from it only the albuminous matter, which they have the property of coagulating at the same time as the oil, and to retain in solution the gelatinous substance. Van Bochaute therefore cannot have found those two matters in the precipitate of the bile by the acids ; for the gelatin can be separated only by the evaporation of the supernatant liquor. This last has not yet been proved to exist in the bile, and hitherto there has only been found in it the albuminous substance which

which, renders this liquor ropy and viscid, and the proportion of which varies according to a number of circumstances.

52. *G.* The saccharine substance, or the substance analogous to the sugar of milk, which Cadet first announced in the bile, but which he has not demonstrated to exist in it by sufficiently accurate experiments, has formed, as I have already indicated, one of the principal objects of Van Bochaute's researches. The latter was not able, notwithstanding the different means which he employed, to insulate this principle and render it sensible. He judged of its presence only by the sweetish taste of the extract of the bile, and by the commencement of vinous fermentation which he thought he observed in it. We are however astonished, when we reflect how little success he obtained, to find this author in his recapitulation, enumerating the saccharine mucous substance amongst the most abundant principles of the bile, and even indicating it as being very analogous to sugar. It is impossible to accede to the opinion of Van Bochaute, while no processes have been discovered for better proving the existence of this saccharine matter in the bile. Such a substance should rather appear to be foreign to this oily, acrid, and bitter liquid, were it not considered, on the one hand, that indications seen by able chemists ought to call upon their successors to confirm them by new researches, and on the other, that it would not
be

be extraordinary if a liquor, formed in part by the absorption of the products of the intestines, should contain a portion of chylous matter. Those notions therefore deserve to be followed up by farther researches; and if the saccharine matter actually exists in the bile, we shall be led to regard it as one of the recrementitious substances which this humour carries into the organs of chylification.

33. *H.* The chemists who have hitherto occupied themselves with the analysis of the bile, have written scarcely at all concerning the nature of the salts that are contained in it; they have almost all operated by treating it with the acids; and they have confounded the salt formed by this addition with those which form integrant parts of this liquor. I have shown, by the re-agents, indications of phosphoric acid and of lime in the bile. The soda is equally super-abundant to the saline combination, since the exceeding part exists in it in the saponaceous form. It is therefore certain that this humour contains phosphate of soda and phosphate of lime. There have besides been found in it some indications of muriate of soda. There is reason to believe that the saponaceous and albuminous state of this liquid contributes to render the calcareous phosphate soluble in it; for it cannot exist in the state of phosphoric acid, on account of the soda which is almost insulated in it. We see the same circumstance of the solution of this earthy

earthy phosphate in the animal liquors. Sometimes this phosphate of lime is sufficiently abundant to form concretions as in other regions of the animal body. I have several times found some, of this nature, in the texture of the liver of certain animals, and especially of birds.

34. *I.* Hitherto iron, in the state of oxide, has been reckoned amongst the constituent materials of the bile; and it appears that Gaubius, in his Lectures, believed this oxide to be the cause of its colour. But without denying the possibility of the existence of this metal in the biliary liquid, though its coal but rarely presents any but merely slight traces, we cannot be permitted to attribute to this metal the source of its yellow or green colour, because this colour is so easily altered by the oxygenated muriatic acid. The iron is therefore only a principle in some measure accidental in the bile, and does not sensibly influence its nature or its properties. Formed entirely at the cost of a venous blood singularly retarded in its course, it would be astonishing if the bile did not contain the ferruginous substance which is so easy to be exhibited in the sanguineous liquid; and we might even rather find the smallness of the quantity of this metal existing in the bile a subject of embarrassment, if we were not accustomed to see several liquids separated from the blood which contain none at all of it. Neither do we know in what state the small quantity of iron that has been indicated in the bile exists;

and if, as in the blood that furnishes it, this metal be not combined with the phosphoric acid, it affords another subject of research which the chemist ought not to neglect.

35. The nature of the texture of the liver, though not yet analysed comparatively, with other visceral parenchymas, has presented some facts which may throw light upon its functions, and which must here be collected. I have already remarked that this texture has not a bitter taste, and that it thus indicates that the hepatic bile differs essentially from the cystic. In the year 1785, I had occasion to examine chemically a portion of human liver, that had been suspended for ten years in the air, in the laboratory of Poullatier de la Salle. This parenchyma, after having undergone the phenomena of a slow putrefaction, resembled a friable and light earth; and the first notion of a chemist, at the sight of it, would formerly have been that it was actually reduced to its earthy skeleton. It was, however, fatty, smooth, and, as it were, saponaceous under the finger; upon an ignited coal it was softened, melted, blackened, and reduced to coal; exhaling at the same time a smell of fat; it afforded me water slightly ammoniacal, a concrete and lamellated oil, carbonated hydrogen gas, and a light coal in the retort; boiling water dissolved a small quantity of it, and assumed a saponaceous character; the residuum, which was more oily or greasy crystallized as it cooled, and inflamed with

SECTION V.

Of the Varieties of the Bile in the different Animals.

37. WHAT has been done with regard to the analysis of the bile of the bullock, the fluid most commonly examined, proves that this liquid ought to be considered as an albumino-saponaceous liquor, composed of water, of albumen, of soda, of a particular concrescible oil, of phosphates of soda and of lime; that the colouring principle, the volatile and odorous oil resembling myrrh, are only products of the alteration of this liquid; that the mucofo-saccharine matter is not proved to exist in it; and that the iron is only accidental to it. The materials that have been first indicated form the principles of the bile, and the experiments that have hitherto been made upon the human bile compared with that of the bullock, have not shown any differences between these two liquids. But we are not authorized to conclude, from these two analysis, that the bile is of the same nature in all animated beings. There is reason to believe that the species of mammalia that have no gall-bladder, and possess only hepatic bile, have a particular character in this liquid, in particular less acrimony and bitterness.

38. Nothing

38. Nothing has yet been done respecting the analysis of the bile, as considered in the different orders or genera of animals; the varieties in the nature of the biliary liquid which the difference of organization in the viscera must produce have not yet been examined. Anatomy, more advanced in this respect than chemistry, teaches, however, that the hepatic system or apparatus, which, as I have already said, is constant throughout the whole series of animated beings, having a structure more or less remote from the original type or the original model which we find in man and in the mammalia, the different animals must also have a diversity of nature in their bile. Undoubtedly the bile of the carnivorous and the frugivorous birds, whilst it differs in these two grand classes of bipeds, differs still more from that of man and of the mammalia. Still more must there exist a peculiar character in the bile of the amphibia, of fishes, of the testacea, of insects, and of worms. Much use was formerly made in medicine of the bile of the carp, of the pike, and of the eel; it was prepared in pharmacy by evaporation, and it was inspissated to an extract. The art of performing this simple operation has shown that this liquid is of a deep and brilliant green in fishes: that it is not so viscid as that of man, and the mammalia; that it is less bitter; that it thickens like a varnish; that it attracts the humidity of the atmosphere when it has the form of extract; that

that it is very miscible with water; that it becomes turbid, and precipitates whitish flakes by the addition of alcohol, which itself remains green.

§9. Hitherto I know only of an analysis of the liver of the skate, made by Citizen Vauquelin, which, whilst it proves the adipose nature of this viscus, announces that the bile of the amphibia and of the fishes must be more oily than that of the mammalia and of the birds. It was already known in the kitchens, that when the liver of the skate, which is soft and of a reddish-grey colour, is boiled in water, it assumes a firmer consistence than it had before, and lets some oil escape, which is seen swimming upon the surface of the liquor. This oil does not become fixed at sixty degrees of temperature. Triturated with water in a mortar, the liver of the skate presented to Citizen Vauquelin a sort of emulsion or oil, which gradually separated at its surface, and was decomposed by the acids. Paper is greased by this viscus, and the syrup of violets is turned green, because the liver of the skate, when examined at Paris, at a distance from the sea-ports, is already slightly altered. The red colour, given to turnsole paper by an acid, and again converted into blue by this liver, passes again into the red, in the air, by the volatilization of the ammonia, the presence of which is proved by this change. When bruized skates' liver is slightly roasted, some drops of oil issue from it; and

and when afterwards subjected to the press, it yields more than half its weight of oil: the portion of parenchyma which remains after this expression, when burned in a crucible, leaves pure phosphate of lime as its ashes. The oxygenated muriatic acid, poured upon the oil extracted from the liver of the skate, renders it immediately white, whilst at the same time it loses its smell, and gives it the consistence of fat; this oil, exposed to the air, becomes white, concrete, and opaque. Citizen Vauquelin concludes from this examination, that the liver of the skate (and the bile of this animal undoubtedly partakes of the same nature,) is charged with a liquid oil in very large quantity. He compares this fact with the livers of fattened animals, and especially those of geese, which are very sweet, very fat, and of a pale colour, and with morbid circumstances under which the human liver and that of the mammalia becomes tumefied, white or grey, and assumes the fatty character which that of the skate presents. He attributes this oily nature, and especially this liquid oil, to the circumstance, that the blood of the abdominal viscera, being very much retarded in its course, especially in the animals that respire little, becomes much hydrogenated in proportion as its carbon unites with the oxygen absorbed by this fluid, and that it is on account of the extreme slowness of its motion in the skate, that the oily matter formed in it remains always liquid.

40. This single circumstance of the analysis of the liver of the skate, which affords ground to believe that the bile follows the oily kind of composition in this animal, and which shows a remarkable relation between respiration and bilification, is sufficient to show how many important results in physiology and medicine might be derived from the experiments made on this humour, compared in the different genera of animals; how many useful conclusions in animal physics, and the art of healing, may be expected from the careful execution of the plan of researches proposed by the programma of the national institutes. How much may not be expected, when the zeal of chemists shall engage them to pursue this important investigation in the different ages of man, and of the animals, in the foetus that has not respired, in subjects afflicted with pulmonary diseases, and in whom the impeded respiration seems to be reduced to a condition similar to that of the amphibia, in all the affections in which this liquid assumes so many characters and properties which cause it to differ from its natural state? How many problems, not only hitherto undetermined, but even yet unthought of, will result from these numerous and useful experiments, which have scarcely been commenced, and are already so important, on account of the views which they afford to the science of healing.

SECTION VI.

Of the Uses of the Bile in the Animal Economy during Life.

41. I HAVE but little to say here respecting the uses of the bile, because this subject will be treated in its proper place in the fourth order of facts, which will conclude this eighth and last section of my work. I shall confine myself, in the present article, to the general facts that are inseparable from the chemical history of the bile. Till the period when chemistry enlightened animal physics concerning the formation of this humour, respecting its relations with the abdominal blood, with respiration, with the fat, physiologists limited themselves to consider of the bile as a liquid useful and necessary to digestion, by its property of mixing oils with water, and consequently of forming the chyle. But the notions that flow from the present researches are much more comprehensive; and, we may affirm with truth, that they have opened a new career for the progress of animal physics.

42. It is well known, that the secretion of the bile consists in its discharge into the duodenum. Haller believes, and besides the weight of this author's opinion, the

notion is supported by simple and accurate reasoning upon the anatomical structure, that the hepatic bile descends much more abundantly into the intestines than into the gall-bladder, and that only a small portion of it passes into this reservoir by a kind of overflow. So that the hepatic bile flows incessantly from the liver into the intestinal tube; but the cystic bile arrives in it only at certain periods, by the change of situation in the abdominal viscera. It is at the moment when the aliments being already dissolved and digested, arrive in the duodenum, that the bile of the gall-bladder, which is elevated towards its bottom, evacuates itself and flows into the duodenal cavity after having been mixed either with the hepatic bile, or with the pancreatic juice, the excretory duct of which unites with the extremity of the ductus choledoctus within the sides of the intestines themselves. The changes which it experiences, by its mixture with this last-mentioned juice, are hitherto unknown; for the simple notion of its division, its attenuation, and its mollification by this juice, is little satisfactory to the mind accustomed to observe that nature, in her admirable economy, does not go to the expense of creating a glandular viscus, for the mere purpose of diluting a humour, to which she would have contented herself with giving more fluidity in its own secreting organs; and the less so, as we see on the other hand, in this theory, no use for the gall-bladder, except that of serving to thicken

thicken the bile. Were these notions just, it would follow that those animals which are destitute of a gall-bladder, and in which the bile is not so thick, must have no pancreas; whereas frequently, on the contrary, this gland is more perfectly formed in them than in the animals which have a gall-bladder. We are not therefore yet in possession of the whole truth respecting this subject.

43. The bile, poured upon the alimentary mass digested in the stomach, appears there to undergo a decomposition, of which nothing is said in the works on physiology. Besides that the aliments are generally more or less acid, which is sufficient for the precipitation of the biliary humour; had they not this character, their very compounded state would be sufficient to render it conceivable that the slight equilibrium of the composition of the bile could not resist it. It undergoes a precipitation, it is divided into two matters like the chylous mass itself; the one liquid, containing the alkali, the salts, with part of the animal substance, and the saccharine substance, if it be present, combines with the most soluble and most fluid part of the digested aliments, and forms the chyle with them. The other matter of the bile, composed of coagulated albumen, and of coloured, concrescible, acrid, and bitter oil, is precipitated grumous, concrete, or disposed to assume this state with the undissolved, feculent, solid, ligneous, osseous, and undigested part

of the aliments, with which it is condensed along the intestinal tube, which, by its contractions, expresses from it the chylous juice, sucked in by the mouths of the absorbent vessels, and gradually dries the mass destined to be discharged out of the body in the form of excrements.

44. Hence it appears, that the bile, being partly recrementitious, and partly excrementitious, effects, by a real chemical action, the first separation of the alimentary mass, which passes homogenous from the stomach; that it tinges the residue, which forms the excrements, with its coloured oil; that it is this also which gives them the greater part of their fetid smell, on which account, when obstacles impede its passage into the duodenum, or when it does not flow from the liver, the excrements are without colour or fetor. It acts also as a stimulus, which irritates the sides of the intestines; it excites their contraction, and thus causes the aliments to make their transit through this tube; at the same time it causes the flow and expulsion of the mucous and glairy juice of the intestines; its action is even purgative in some cases: sometimes being too stimulant or too irritating, it excites pains, pricking sensations, cholics, and gives rise to abundant evacuations. Accordingly, the extract of the bile frequently supplies by art, the deficiency of the bile, and remedies, if prudently administered, that
 sluggishness

sluggishness of the intestines, which the want of this liquid necessarily produces.

45. As the oily, coloured, and acrid matter of the bile, being separated from the foda, is thus discharged in the form of excrements, with the superabundance, or the residuum of the food exhausted more or less of its alimentary portion, it must be concluded that this kind of excretion is the means which nature employs for expelling from the body of animals this equally superabundant oily substance. It was in this manner that Roux conceived the expulsion of what he believed to be the colouring part of the blood, which he considered as a matter that was acrid and pernicious when it had several times passed through the sanguineous ducts, and to the retention of which he attributed the production of various diseases. If this hypothesis, which a more accurate knowledge of the blood renders less natural and less probable, should be discovered to be really erroneous, we must always admit in this evacuation of the oily and irritating part of the bile, a course by which nature disburthens the animal body of a superhydrogenated principle, of a superabundance of hydrogen; and this view, which I believe will be more and more confirmed by an attentive observation of the phenomena of respiration, and by the comparison of the pulmonary affections with the state of the hepatic and biliary system, is even now a very advanced step in the knowledge of one of



of the chemical effects of vitality and deserves the most serious attention on the part of physicians. It will naturally accord with a multitude of facts which it is not my object to set forth in this place, but the announcing of which to those who are engaged with animal physics, will be sufficient to induce them to study it with attention.

SECTION VII.

Of the Medicinal and Economical Uses of the Bile.

46. PHYSICIANS have long employed the bile or gall of the bullock, inspissated to the consistence of an extract, and frequently under this name, as a tonic, stimulant, solvent remedy, and especially in order to promote digestion. They have supposed that whilst they supplied by this administration the deficiency of the bile in subjects with whom it is imperfectly secreted, they should restore to the functions of the primæ viæ a principle which they wanted for effecting the complete digestion of the aliments, for irritating or stimulating the intestinal tube, favouring the motion of the alimentary mass, and thus procuring almost natural evacuations, and remedying the evils to which the detention of the bile in its reservoirs gives

gives rise. Experience has proved that a part of these views might in fact be fulfilled by the judicious use of inspissated bile, and it is frequently made one of the ingredients of the medicines commonly employed in such cases; for the extract of bullock's bile is never administered alone, and without being associated with other substances; it is mixed with extracts of aperient, solvent, incisive, bitter plants; it is administered in electuaries, pills, boluses. It ought always to be remembered that this extract is very deliquescent, that it becomes soft by exposure to the air, that it causes the pills and boluses, into the composition of which it enters, soon to lose their consistence, and that consequently they must be prepared in small quantity, and frequently renewed.

47. The notions respecting the properties of bile as a medicine, have, however, been much abused. Enthusiastic, or credulous physicians, have not only attributed to it many more virtues than it actually possesses, and have employed it with profusion in a multitude of different affections, in which its action may be detrimental, or in which its little effect has given occasion to others to accuse it of want of power or utility; but these exaggerated notions have been carried so far as to fancy specific properties more or less absurd in the bile of such or such an animal. In high estimation has been this bitter liquid procured from fishes, especially from the eel, the carp, and the pike; and the preference

preference has been given to the one or the other in different pathological cases. In short, fictions and absurdities have been mixed with the simple and sufficiently just ideas which had first been entertained respecting the properties of bile in general; so that in a manner the confidence has been diminished that might deservedly have been placed in the extract of bullock's bile, which, in fact, is the best known, and the best analysed of these liquids. For it is to be remarked, that whilst admirable properties were asserted in the bile of the eel and of the carp, no chemical examination had been made of those species of bile, nor had we endeavoured to acquire any real knowledge of their differences from the bile of the bullock.

48. The most frequent and general use of the bullock's gall, is that to which it is applied by the fullers. The butchers sell it them by the name of *amer*; the gall-bladders of these animals are full of bile; and the fullers employ this liquid for taking out the fat and oil from the woollen stuffs; and as the bile acts very well upon those spots, which it causes to disappear, it was long ago inferred that this liquid was of a saponaceous nature. In proportion as the oil is carried away by agitation and friction with the bile, this becomes frothy, especially with the first portions of water, which are thrown upon the cloth in order to wash it.

Bile enters also into the composition of several colours; inspissated into a solid or dry extract, when it is diluted in a little water, and affords a brown *bistre* colour. It is for this purpose that the painters employ the biliary calculi of the ox, as I shall remark in the following article.

ARTICLE XXII.

Of the Biliary Calculi.

1. IT might seem very natural to treat of the nature of the biliary calculi in the history of the bile itself, since this liquor gives rise to them, and since they appear to be of an analogous composition. Most medical authors who have spoken of them, have in fact regarded them merely as bile become concrete, and have thought that they were produced only by the too great inspissation produced by a long continued detention of this liquid, either in the biliary pores, or in the gall-bladder. But as the analysis of these concretions has presented to me results considerably different from those which the chemical treatment of the bile presents, I have thought I ought to separate the examination of their properties from that of this humour, in order that I might more effectually excite the attention of persons of the art, and
prove

ove that conclusions borrowed from analogy, and the mere probabilities respecting the nature of the bodies, almost all fall short of the truth, and ought never to be substituted for experiments, which alone are capable of discovering it.

2. Many authors have spoken of the biliary calculi, their physical properties, their differences from other animal concretions, and even of their chemical properties. Amongst the physicians, for they alone had in some measure the claim to interest themselves in the subject, on account of the relations which they have with the production of the symptoms, and with the cure of diseases, the following are particularly to be distinguished. Columbus found one in the confluent of the vena portæ, at the orifice of the corpus sti. ignatii. Glisson, Bianchi, Hoffman, have written very copiously upon these calculi. In 1749, Haller collected, in a programma, a great number of observations upon this subject. Walker, in his folio work on the concretions of the human body, which he improperly calls earthy, has described the biliary calculi with much accuracy, and distinguished them according to their structure, into classes, genera and species. Vicq d'Azyr, in the collection of the Society of Medicine for 1779, has described, with a number of details, nine remarkable species, and has also proposed a new classification of them. These two last anatomists have subjoined figures to their descriptions.

scriptions. As to the chemical inquiries upon these concretions, Haller in his history of the bile, has consigned the principal results obtained till in the year 1764, when his great physiological work was published. He has collected all the chemical facts observed till then by Hartman, Moseder, Hales, Taconi, Strohlen, Wieufens, Valisnieri, Grew, Boerhaave, Ludwig, Spielman. But all these authors have observed only some facts, they have examined only some insulated properties; none of them has made a connected or exact analysis of them. From the consideration of all these facts, we see that the biliary calculi are only partially soluble in water; that they are more soluble in alcohol; that they are light, oily, inflammable; that the caustic alkalies soften and dissolve them, as does the oil of turpentine, and even the fixed oils: that the nitric acid also dissolves them; that they become soft in the fire, like wax; that most of them are insipid or mild; that their centre, or nucleus is bitter: that in general they differ greatly from the urinary calculi. For the rest, all these properties have been announced as inconstant and variable.

3. Poulletier de la Salle first discovered, that when the biliary calculi were treated with hot alcohol, this liquid afterwards presented, by cooling, a number of brilliant, crystalline filaments, which he compared to the boracic acid, or to the flowers of benzoin, the nature of which he had not examined, not having been able

able to procure a sufficient quantity of them for that purpose. I have learned from him that this singular matter, which had not been described before, was more soluble in hot than in cold alcohol, that it was separated very quickly from it by cooling, that it existed in small quantity in these concretions, and that it was not met with in the biliary calculi of the bullock. This animal is very much subject to concretions of this kind; they are found in its gall-bladder, especially in the winter: the butchers extract them with care, and keep them for the painters, who make use of them in their designs. Van Swieten remarks, that in the spring, when the cattle eat the fresh herbage, the biliary calculi are dissolved, and that it is on this account that none of them are found at this season or in the summer. Hence he even concludes, as Haller also does, that the juices of herbs must be very good solvents of these concretions, and asserts that medical experience actually confirms this important notion derived from natural history.

4. In 1785, after having collected these facts from the mouth of Poulletier, the examination of the liver putrefied and dried in the air, in which I found the concrescible oil I have spoken of, led me to suspect that the crystalline laminæ of the biliary concretions of the human species might probably be of the same nature; and having treated in this view, all at once, a considerable quantity of biliary concretions

cretions which I kept in two dry gall-bladders that were filled with them, with hot alcohol in the proportion of sixteen parts to one of these concretions, I observed that the yellow solution which I obtained, quickly deposited by cooling a remarkable quantity of brilliant filaments, the properties of which presented to me a remarkable analogy with the oily matter of the liver dried in the air. When heated in a silver spoon, these crystals, which had a fat and unctuous feel, melted into a yellowish oleagenous liquid, of a much less volume than their own, which smell like wax, and which, after cooling broke into brilliant laminæ. I have since ascertained that this matter does not melt, unless the temperature be raised to nearly 90 degrees of the thermometer. Soda and caustic pot-ash dissolved it completely, and brought it to the saponaceous state; the nitric acid likewise dissolved it, without ebullition or effervescence, and formed with it a species of liquid analogous to the oil of camphor. This last property completed my conviction that this crystalline matter of the biliary calculi has great analogies with spermaceti; and it was from the comparative examination which I made of it, in different circumstances in which I have since found it in animal matters become fatty by putrefaction, in the decomposed brain, &c. that I have named it in general adipocire, distinguishing it, however, into several varieties, according to its different degrees of fusibility, of solubility in alcohol,

fibres or not; in the second, the calculi composed of a brilliant crystalline substance, with or without a covering; and in the third, the mixed biliary concretions, formed of yellow biliary matter and crystalline substance. We see, that instead of following the form alone like Walker, Vicq d'Azyr began to perceive the possibility of distinguishing the biliary calculi according to their nature, though he was ignorant, in 1779, what the crystalline substance was that was contained in them.

7. I now reckon six genera of biliary calculi.

The first are the *bilious hepatic*, composed almost solely of thickened bile, deposited in irregular clots in the texture of the liver itself; these are rare.

The second are the *hepatic adipocirous*; these are found sometimes in narrow laminae, forming solid points in the parenchyma of this viscous; sometimes they are prominent upon its surface, exhibiting small white or yellowish tumors; they are very rare in this place; frequently, perhaps, very small ones of this kind are discharged, and run off with the bilious evacuations.

The third I call *cystic bilious*: these are concrete balls, or flakes of thickened bile, granulated, irregular, very various in form and consistence, sometimes friable, brown or reddish. The calculi of the gall-bladder of the bullock which the painters use, are of this kind.

Th

The calculi of the fourth genus are the *cortical*, of the same nature with the preceding; they are only more dense, and covered with a grey, or white smooth layer, well terminated with adipocire. They hold the second rank with respect to their frequency. They are frequently found in great numbers in the gall-bladder; sometimes even they exceed a hundred in number: they are then polygons, situated close to each other like pieces of mosaic work, and distend the bladder more or less.

The fifth genus consists of the *cyctic adipocirous* calculi; they are white or grey, opaque without, or semi-transparent, granulated or smooth, covered with a crust of short filaments, or without crust, formed of entire laminæ in their whole thickness. or of rays proceeding from the centre, and diverging to the circumference: very frequently they are single, and they have then the form and size of pigeon's eggs. They are more rare than the preceding; they are most frequently found in women. At the termination of bilious diseases, and almost always of chronic jaundice, irregular calculi of this sort, somewhat dry, or solid, rather granulated than crystalline, soft, similar to tallow, and yellowish, are discharged with the stools. This kind of adipocirous, or fatty evacuation, is much more frequent than has been believed, and may be observed in many subjects when their dejections are carefully examined at the termination of diseases.

Finally, I refer to the sixth genus the *mixed cystic*, or *adipo-bilious* calculi, which are mixtures of adipocire and thickened bile in various proportions: these are the most frequent of all, and like those of the fourth genus, they are numerous: they are frequently found mixed with them; sometimes brown, or of a deep green, or olive-colour, we see more or less easily in their interior, brilliant streaks, or lamellæ, of a deep yellow colour, or only some micaceous points. When they are polyhedral, we observe upon their worn sides, edges of broken crystalline laminæ.

8. All these calculi, being soluble in the caustic alkalies, in the solutions of soap, in the fixed and volatile oils, in alcohol, and partly even in ether, may be made to yield and disappear, or soften, and even dissolve by the use of these medicines when they are able to reach them. They ought to be attacked with these remedies, administered in a proper and judicious manner. Ether, combined with white of egg, is especially very useful in allaying, at the same time, the spasm and the contraction which these calculi produce in the gall-bladder. Frequently the ductus cysticus, and the ductus choledochus dilate themselves in an extreme manner, in order to afford them a passage. These tubes, which are generally of the thickness of a small quill, have sometimes been found so much augmented in their diameter, as to suffer the finger to pass easily from the duodenum to the base of

the liver; but most frequently their volume, or their number, occasion the death of the patients.

ARTICLE XXIII.

Of the particular Animal Matters contained in the Intestines.

SECTION I.

Of the Intestinal Humour.

1. AFTER the gastric, pancreatic, and bilious juices, it is necessary to examine those matters which are met with in the intestines, because these viscera follow after the stomach, and since they receive the liquids which must act upon them, and upon the matters which are contained in them, and these must likewise act upon these liquids already known. Five particular substances present themselves to the observer in the continuity of the intestines. One of these substances derives its origin immediately from the sides and the functions of this tube; this is the intestinal juice. The four others, though peculiar to this canal, proceed from the extraneous matters which pass through it: these are the chyle, the excrements, the gases, and the intestinal calculi. Of these four matters, the two first are constant, and in the natural order;

those of the third genus, though very frequent, vary remarkably in their quantity and their nature, and abound only in a state of disease; and those of the fourth kind are always the product and the cause of morbid affections. In the examination of these five substances, I shall be obliged to avail myself of anatomical or medical observations, for want of chemical experiments; for those which have been made, either date from periods very much advanced for the art, or are only imperfect essays, upon which hardly any reliance can be placed: I shall nevertheless indicate the least inaccurate of these imperfect analyses.

2. The sides of the intestines are impregnated through their whole continuity with a humour which has been called the *intestinal juice*, and which performs several important functions in this alimentary canal. Haller has represented this juice as a mixture of bile, of pancreatic juice, of the residues of aliments, of the mucus, of the intestinal pellicles, and of a humour exhaled by the arterial extremities. According to him, however, this last is the most abundant of all, and may be considered as the true intestinal liquor. It has, indeed, been impossible hitherto to examine this liquor pure and insulated, because no means are known for separating it from the other humours which are mixed with it; but its quantity, which is superior to that of the others, justifies the belief that the properties which have been observed in the totality of these

these liquids belong really to the intestinal humour, and may be considered as its true characters.

3. The surface, from which the intestinal humour exhales, presents an immense organ, which Haller believes to be at least equal, in its energy and in its product, to that of the whole surface of the skin. The same anatomist observes, that the arteries, the extremities of which pour out this humour, equal, at least, in the sum of their diameter, that of the two venal arteries; so that the mass of the liquid exhaled, were it estimated only according to the quantity of surface which furnishes it, would appear to approach remarkably to that which is secreted by the kidneys, as this approaches to that which is evaporated by the skin. Haller, according to calculations founded upon measurements of the length and the internal surface of the intestines, goes even so far as to believe that about eight pounds of intestinal humour is separated in twenty-four hours; which is twice as much as is discharged by the skin: it is to this that he attributes the immense quantities of aqueous liquids in some diarrhoeas, and at certain periods of dropsies. But these last-mentioned circumstances differ too much from those of the healthy state, for it to be possible to conclude any thing from them for ordinary cases; and as to the calculation of the learned Haller it is too little supported by accurate bases, to induce us to believe that the proportion

proportion of the intestinal liquid is twice as much as that of the transpiration. There is merely reason to believe that it is not much different from that of this insensible evaporation.

4. All the physiologists, who have spoken of the intestinal humour, have believed it to be of the same nature with that which is separated upon the interior surfaces of the pleura, of the pericardium; and to this comparison they have confined themselves. Some observations, both after the stools, and upon the dejections, which have been considered as proceeding from the greater abundance of this humour, have caused them to consider it as viscous, ropy, thick, glairy, or mucous. Pechlin and Brunner have found it coagulable by fire and by the acids. It has been observed concrete, and formed into laminæ and fibres, or in thick clots, lining the sides of the intestines, and adhering to them more or less strongly, so that it was even difficult to detach it from them. It has been found altered and fetid, so often as to render it probable that it is very putrefiable; but this property may be attributed as much to its mixture as to the pure intestinal humour, since no chemist has examined it alone. Its uses are, according to the physiologists, and Haller himself, to sheathe and cover the nerves, in order to defend them against the acrid substances which sometimes pass through the intestinal canal, to prevent the sides of the intestines

lines from drying, adhering to each other, or to the extraneous substances which pass through them, to oblund the acrimony of the aliments, to dilute the chimous mass, and to connect together the excrementitious matter, to furnish a part of the lymphatic juice which constitutes the chyle, and to be sucked in by the absorbent vessels.

SECTION II.

Of the Chyle.

5. THE chyle is formed of part of the aliments melted and dissolved by the gastric juice itself, of a portion of the bile and pancreatic juice, and of the intestinal humour absorbed with it by the chylous vessels, which do not differ from the lymphatic absorbents. It is known that it passes pretty rapidly through these vessels disseminated in great numbers upon the intestines, opening into their cavity, traversing the mesentery, anastomosing with one another, uniting and becoming less numerous the more remote, they are from the intestinal tube; forming at least three orders or series of vessels, separated by conglobate mesenteric glands, from the intestines to the lumbar receptacle and the thoracic duct, where they unite, and thus convey the chyle into this duct,
which

which is sometimes double, and most frequently opens into the right subclavian vein, very near the heart. Haller, according to the comparison of a number of facts, estimates that the chyle is separated from the aliments between two and five hours after the repast, and that six hours are almost always sufficient for extracting from the alimentary mass all the chylous substance which it is able to furnish.

6. No chemist has yet examined this humour, and we do not know of any series of experiments indicating that its analysis has even been attempted. It may therefore be asserted, that we are as yet almost entirely ignorant of its nature. Some experiments have, however, been attempted, and observations made by able anatomists and chemists. Haller has collected their principal and most important results in his great work on physiology. I shall here enunciate them briefly, taking care to quote the sources whence they have been taken, and the authors to whom we are indebted for them. I shall afterwards deduce some consequences, and show that we have really no satisfactory notion concerning this liquor, the first origin of the blood, and of all the materials, both in the liquids and in the solids, of which the bodies of man and of animals is composed.

7. Lower, Michelotti, Slare, and Brunner, have found the chyle of a white colour, with

with a sweet or somewhat saline taste, on which account they have compared it to milk. Lister has seen it light, swimming like an oily liquor upon the blood and the serum. Wepfer has observed that a kind of cream was formed at its surface. Bowden, Pecquet, Barthollin, Leidenfrost, Monro, have described its coagulation, which they had observed both in its vessels and round the ruptured thoracic duct. Bohn, Berger, and Asch, have described butyraceous globules in it, swimming upon an aqueous liquor. The same authors have admitted a caseous matter which is precipitated from it, which they considered as more earthy than the rest of the principles of the animal humours, and in which they placed the source of the calculous concretions of the chyle, found in the receptacle itself by Schers, who has described them in a particular dissertation, in the thoracic duct by Le Dran and Bohn, and in the lacteal vessels by Goelike. It is from these different assertions, made by enlightened authors, that the chyle has generally been compared to milk, and that some have even gone so far as to seek the causes and the differences of diseases in the serous, the caseous and the butyraceous matter of this humour, as Astruc has done in his pathology.

8. Bohn and Bartholin have also observed an acrescent property, and even an acid ready formed in the chyle; Birch even asserts that he has seen it redden the tincture of turnsole, though

though Viridet denies the existence of this properly in it; Kulmus, affirms that he has found it present after it had been heated. It has been found that the aliments have an influence upon its characters and properties. Indigo mixed with the food, and received into the stomach, gave it a blue colour in the experiments made by Martin Lister, by Musgrave, and confirmed by the illustrious Haller. They have equally succeeded with Gould and Felix, who have varied them in different ways. Mattei says, he has seen chyle turned red by beet-root. Viridet mentions its having been turned yellow by the yolk of egg. Haller, however, has never been able to discern either of these tinges. Several observers speak of greenish chyle in the animals that feed upon herbage. Mingini has convinced himself by experiments, that iron mixed with the aliment is not found again in the chyle, or that at least it cannot be rendered sensible in it by the gall-nut. But the state of phosphate of iron, in which it is probably introduced into the chyle, does not permit it to be easily coloured by this re-agent.

9. These are the whole of the facts that have hitherto been collected respecting the chyle which have a reference to its chemical properties; but they afford a very imperfect outline of what it would be necessary to know respecting its properties. We shall be able to judge of this imperfection of the science with respect to this subject, from what I am about to say respecting it.

respecting the experiments that have been latterly tried in the School of Medicine of Paris, which the author, my colleague Hallé, has communicated to me. Chyle was collected by opening the thoracic duct of several dogs, five or six hours after having made them eat a cake of milk, flesh, and crumb of bread, with which blue, red, or black colouring matters had been mixed. The dilated thoracic duct was tied in the thorax, and an orifice was made below the ligature. By this means nearly 100 grammes of chyle were obtained, which were made to flow into glass cups. In no case was it found tinged with the colouring matter that had been mixed with the aliments. A very short time after this liquor had been exposed to the air, it coagulated, or rather it assumed the gelatinous form, and presented a sort of curd adhering by its margins to the sides of the cup. There was, under this apparently gelatinous part, a liquid portion, which did not rise to the top till after the curd had detached itself from the sides of the cup. The chyle was thus divided into two parts: the one liquid, of the colour of milk, very thin; the other solid, in a single piece, the parts of which were connected together by a real tenacity, similar to that of the coat which is formed at the surface of the blood in uninfammatory catarrhal affections. This coagulated mass has the semi-transparency of the opal; it has a light red tinge as well at its surface as in the substance

stance and in the portion exposed to the air; this tinge however is more intense at the points of contact with the air. It is cut by a neat section with the scissors, and has no resemblance with the caseous part of milk.

SECTION III.

Of the Excrements.

10. THE excrements are formed in man only in the large intestines; the alimentary mass has not yet their character and fœtor at the end of the ileum, and only begins to assume it in the cœcum. In children they are more soft and more chylous than in the adult. Their softness and liquidity in adults, indicates a weak digestion. Their too great hardness and dryness, which generally causes them to assume the form of separate balls, sometimes goes so far as to retain them for a long time in the large intestines, where they accumulate and constitute masses which may become dangerous. Their most common form is given them by the splinter situated at the extremity of the rectum; and the structure of this part determines the figures which distinguish them, as is well known, in the different species of animals. The fetid smell which characterizes them in man and is peculiar to each individual, though it is of the same description in those of the same species of animals, is attributed, like their colour, to the

the portion of bile that is combined with them, which is considered as having already undergone with the feculent matter, a commencement of putrefaction. When their colour is brown, it depends upon the stay which they have made in the intestines and this colour is commonly joined with a greater degree of solidity. A depraved appetite or an uncommon courage have ascertained that the taste of the excrements is faint or sweetish, and sometimes even strongly acid. Their weight is between 128 and 160 grammes in adults; it is nearly twice as much with those who live upon vegetable food. We may almost always observe in them very distinguishable remains and fragments of solid parts of the aliments, tendinous, ligamentous fibres, barks, and entire seeds: the latter, covered with their tunic, still preserve in them their property of germinating.

11. No true chemical investigation has yet been undertaken which might be considered as an analysis of the excrements. The experiments or observations made by physicians upon these discharges, and some experiments tried with alchemical views which have been much exercised upon this substance, are the only materials from whence we can derive even vague and uncertain notions. Homberg described, in 1711, some phenomena which he had occasion to observe in courageously pursuing several alchemical experiments by which he hoped to succeed in fixing mercury; for these notions and hopes
still

still prevailed during the first years of the eighteenth century. Roth, Grew, Lemery, Macquer, Barchusen, Brownrigg, Pinelli have also made some experiments upon the human excrements; and it is only from these still very feeble sources that we can derive some notions respecting their nature. Grew has seen the excrements effervesce with the nitric acid, become black, and exhale an odorous oily emanation, inflammable by the concentrated sulphuric acid. Homberg extracted from them by distillation on the water-bath, a clear water which formed $\frac{1}{8}$ of their weight and a coloured empyreumatic oil. He could not obtain a clear oil from them till after having suffered them to ferment, and by putting the distilled water which he had extracted from them together with the residue of these excrements thus dried. Roth says he obtained from them a turbid and milky water of an insupportable smell, and he remarks that the residuum of this first distillation was oily. Lemery has described two species of oil furnished by this distillation, the one yellowish and the other highly empyreumatic; he announces also a volatile salt or ammoniacal carbonate forming $\frac{1}{4}$ of the weight of the excrements. Brownrigg and Pinelli agree with Lemery in admitting the presence of muriate of soda in the residuum. Barchusen asserts that there is very little salt in that of the human excrements. Their coal is very inflammable: it is known that it was with this coal, treated by alum, that Homberg, for the

the first time prepared the Pyrophorus, and that he then believed that these matters were indispensably necessary to its production. Macquer has remarked upon the subject of the distillation of the excrements, that they afforded no ammonia upon the first impression of the fire, as putrefied matters would do.

12. The excrements of man and of different animals have also been examined by means of water; though indeed this kind of analysis has as yet been made with little accuracy. Some chemists, especially Homberg, Roth, and Conrad, have extracted by this process a salt which they have said to be nitrous, detonating, forming crystals with six angles, mild and fusible. Some have even spoken of two different salts afforded by this lixivium. It has been remarked that the excrements of cows, sheep and goats give an acid character to water. This property has been particularly observed in the dung of the pigeon, to which some have even attributed an almost caustic activity in vegetation when mixed with the earth. We have descriptions of inflammable vapours disengaged from accumulations of excrements, from privies, and the explosions which they have produced; the fetid gases which have exhaled from these matters, some of which are dangerous and extremely mephitic; and the sulphur which sublimes upon the walls, upon the vaults, and especially upon the surface of their key-stones. Observations made on a large scale on remains of excrements that

that had continued for a long time heaped together have shown that the stones and the masonry which they covered and in the midst of which they had putrefied, were impregnated with sulphur crystallized or deposited in the state of powder. Macquer and Nollet have given an account of plates of silver which had acquired a gold colour by remaining in the sewers of privies, and were converted into sulphate of silver.

13. Citizen Vauquelin is, as far as I know, the only modern chemist who has made some late experiments upon the excrements. He has convinced himself that they are constantly acid; that they redden the blue vegetable colours, that they are especially very susceptible of fermentation; that they at first acquire by this movement a more acid character than that which they naturally have; that ammonia soon succeeds this acidity, and continues till the complete destruction of these matters.

The same chemist has also made some considerably connected researches upon the dung of the pigeon and of the pullet. The first, which is very sour, ferments as soon as it is steeped in water. It appears naturally to contain a peculiar acid: this acid continues to be formed by the fermentation which takes place in it, and is succeeded, after some time, by ammonia, which is abundantly developed towards the termination of this spontaneous movement.

As

As to the dung of the pullet, the object of the experiments to which he subjected it, was to compare it, in its quantity and in its nature, with the aliments given to this animal and with the egg-shell which is formed, as is well known, in the lowest part of the canal which the excrements pass through. He has therefore given the results of the analysis of the egg-shells before these relative to the pullets' dung. The following is a sketch of his comparative inquiry upon these two matters.

14. The shells of eggs weigh upon an average about 5 grammes. Calcined to blackness, they lose about $\frac{1}{4}$ or 0,2, of their weight. After their calcination they afford, during their solution in nitric acid, carbonic acid gas mixed with sulphurated hydrogen gas.

A thousand parts of egg-shells are composed of:

1, Carbonate of lime	-	0,896.
2, Phosphate of lime	-	0,057.
3, Animal gluten and moisture		0,047.

Eggs weigh upon an average about 58 grammes; thus a hen that had laid 130 eggs in six months, would have produced in this space of time about $7\frac{1}{2}$ kilo-grammes of matter necessary for this formation.

15. The dung of the hen calcined gave 5.2 grammes of residuum, that of the cock only 3 grammes.

The 5.2 grammes of hens' dung, burnt and treated by the nitric acid, left 2,33 of insoluble

ble residuum; the 3 grammes of cocks' dung left 1,06 grammes.

The ashes of hens' dung, dissolved in the nitric acid and precipitated by ammonia, afforded 2 grammes of phosphate of lime, and those of cocks' dung afforded 1,17 grammes.

The liquor from which the phosphate of lime had been precipitated from the hens' excrements, mixed with potash, gave 0,185 grammes of carbonate of lime, and that of the cocks' excrements, 0,265 grammes.

Though there remains more calcareous earth in the excrements of the hen that lays eggs, than in those of the cock, this fact is explained by the larger quantity of nutriment which the hens takes at this period, and the more complete digestion of the nutritive substance contained in these aliments.

The excrements of the hen that does not lay eggs, and those of the cock are covered and mixed with a white matter, which is not found, at least not in so large quantity, in those of the hen that lays. This white matter is a kind of albumen coagulated and dried in the air.

Thus it appears that it is this substance which serves to connect together the calcareous parts of the egg-shell, and to give it, in some measure the flexibility which it possesses at the moment when it is laid.

16. Oats, which were the food of the hen upon which this experiment was performed, gave by incineration about $\frac{1}{100}$ of residuum

These

These ashes, mixed with nitric acid, dissolved in part without effervescence; the undissolved portion formed 0,018; the dissolved portion was phosphate of lime, and amounted to 0,005

The portion not dissolved by the nitric acid was pure filix.

Hence it follows that oats yield 0,031 of ashes; that these ashes are composed of 0,393 of phosphate of lime and 0,607 of filix.

In the space of ten days a hen eat 484 grammes of oats, and laid 10 eggs.

The excrements which she discharged during this time having been burnt, yielded 39 grammes of ashes, which gave by analysis, 1,77 grammes of phosphate of lime; 22,6 grammes of carbonate of lime; 38,5 grammes of siliceous residuum.

A formation of lime and of phosphoric acid has taken place in the body of the hen; for 1. the excrements of the hen afforded 2,6 grammes of carbonate of lime, and the oats yield none 2. again, the hen laid during this period 4 eggs, the shells of which weighed together about 20 grammes; which forms a sum of 22,6 grammes; and 3. the oats also afforded only about 6 grammes of phosphate of lime, and the excrements of the hen which were formed from them furnished nearly 12 grammes.

When we compare the quantity of filix found in the oats and that of the excrements of the hen that was fed upon them, we find 9,34 for the oats and only 8 in the excrements which

proceeded from them: there is therefore a deficiency of 1,3 grammes.

Must we thence conclude that it is this filix that has served to furnish the excess of lime? For this purpose it would be necessary that it should absorb nearly five times its weight of an unknown principle.

17. It results from all these facts, which are the only ones that yet exist in the history of the art, that there is no collective whole, no system of analysis of the excrements; though we may find in these researches an useful application to animal physics. We see however now that this kind of inquiry may throw great light upon the digestion of the aliments, and that it is of importance to undertake it immediately, since the means are now both more numerous and more certain. A comparative examination of the vegetable or animal aliments, before those aliments are given to an animal, of these same aliments digested in the stomach and in the intestines; finally, of these matters when they have become excremental, either whilst still contained in the large intestines, or after they have been discharged from this canal, must lead to an exact determination of what happens in the charges affected by digestion, how much matter is absorbed by the chylous vessels, in what proportion it is discharged, and especially the different states which it acquires at different periods of this function. All this belongs to the province

vince of chemistry, and what is wanting to physiology must be furnished by this science.



SECTION IV.

Of the Intestinal Gases.

18. THE intestinal tube is frequently distended by elastic fluids, which are discharged with or without noise from its extremity, and constantly accompany the digestion of the aliments. Their disengagement, which varies much in proportion, both according to the aliments, and that of liquids diffused in this canal, as also according to the state itself of its interior surface, seems to depend upon a fermentation of the alimentary mass, and it is to this movement that their production is commonly attributed. It is however known at present, that there may take place in the aliments chemical changes adopted to extricate elastic fluids, without the existence of a real effervescence, which, being admitted by the school of Sylvius, might have been considered as the source of these intestinal gases. In order to understand this gaseous disengagement, it is sufficient to acknowledge a chemical modification of the alimentary mass, mixed with the liquids existing in the intestines; a modification similar, for example, to that which is produced

duced by the action of the nitric acid, when converting these substances into oxalic acid, into adipocirous matter, and into bitter yellow substance, it dissolves a part of them into azotic gas, carbonic acid gas, and Prussic acid.

19. In whatever manner this formation of gas is effected, and to whatever cause it is to be ascribed, it is known that it takes place more frequently and more abundantly in the large intestines than in the smaller; that it sometimes produces considerable distensions; that the colon is especially attacked with this disorder; that it is frequently contracted at the two extremities of the dilated part, the volume of which then exceeds several times that which it naturally has; that in the most ordinary cases, the true and peristaltic force of the intestines re-acts upon these elastic fluids and propels them to the anus through which they escape out of the body. I have already remarked that there is no digestion in which such gases are not formed and disengaged. We have multiplied proofs that the farinaceous vegetables, especially the leguminous seeds, possess, in a more especial manner than the other kinds of aliments, the property of producing elastic fluids; and it is on this account that they are called *flatulent aliments*. As these substances are subject more than others to enter more easily and strongly into fermentation, it is evident that it is by the spontaneous change which they

they experience in the primæ viæ, that this disengagement is produced.

20. Formerly nothing was stated concerning the nature of the elastic fluids produced by digestion; they were all confounded with the air, and this was the only assertion respecting their intimate properties that was to be found in all the works of physiology. Their fetor had however been insisted upon, and it was vaguely attributed to putrid matters which the air carried along with it. It had also been observed in some circumstances that this pretended air was susceptible of inflaming, and the relation which presented itself under this point of view, between this intestinal emanation and the combustible fluid disengaged from the feculent matter putrefying in privies had also been noticed. It is only since the new discoveries respecting the difference of the elastic fluids, the properties which characterize each species in particular, and especially the means of separating them, and determining their nature, that we have been able to know these bodies better and to ascertain that they are not atmospheric air.

21. In the gases issuing out of the intestines carbonic acid gas has been found in great abundance; and it generally constitutes the greatest part of such of these fluids as are without smell; carbonated and even sulphurated hydrogen gas, though the latter is rather rare: these two last are more or less fetid and
burn

burn with a blue flame at the approach of a lighted taper. These gases are easily collected above the bath when the body is immersed in water: it has been pretended for some time that some of these gases, particularly carbonic acid gas, issued also through the pores of the skin; but this assertion still wants confirmation. It has been found by observations, which now are considerably numerous, that in ordinary cases, it is carbonic acid that is disengaged in easy and quick digestion, and that the indigestions accompanied with uneasy sensations and extraordinary motions pretty constantly give rise to carbonated or sulphurated hydrogen gas. Thus it happens, that when the intestine of a horse or of a bullock is punctured with a trocar, as is usually done in order to relieve the violent pains which arise from its dilatation, the gas which escapes in consequence of this operation suddenly inflames upon the approach of a candle. It has also been believed that there was azotic gas amongst the elastic fluids of the intestines; but as it is certain that the atmospheric air penetrates this organ, and that some of it constantly passes with the alimentary bolus, there is reason to believe that it is the same with this gas as with the portion of oxygen gas which is found in them at the same time. Both proceed from the quantity of air contained in the aliments, swallowed down with them, and disengaged by the heat of the intestinal tube.

SECTION

SECTION V.

Of the Concretions or the Calculi of the Intestines.

22. SOMETIMES concretions or kinds of calculi are formed in the intestines of man : their sides have been found lined or covered with a kind of crust sufficiently hard to have been called *stony*, and more frequently bodies that have passed slowly through their canal or remained for a long time in it, enveloped or incruited with solid or crystalline layers. A musket-ball, a bone, the kernel of a fruit, a piece of wood, small shot, calculi of the gall-bladder, have several times become center, round which layers of solid substance have collected in the intestines. In the animals these formations of intestinal calculi are still more frequent ; and the horse is extremely subject to this kind of concretion, which frequently acquires a very considerable size and weight. Besides those nuclei of calculi foreign to the intestines, there are some also which are peculiar to them and which are formed without requiring these accidental bodies. We must not here omit to mention those masses of agglutinated hairs, felted and pasted together with intestinal juice, which gives them their adhesion and solidity, nor the
stercoral

stercoral calculi proceeding from excremental matter retained and condensed in some of the folds of the great intestines.

23. Thus several matters, especially the bile, the pancreatic juice, the intestinal juice itself, the remains of aliments, may give rise to calculi which must differ from each other by their colour, their texture, their density, their form and especially their nature. Chemical analysis easily enables us to distinguish them from each other, and though we have not yet had a consecutive series of researches upon this subject, it is not necessary to enable us to know how to determine the composition of each species of these calculi. I have indicated in the history of the genus and of the species of phosphates, that of magnesia and ammonia as forming the species of intestinal calculus of the horse, which is called though improperly, the *Hippolitha*. I am inclined to believe that the pancreatic humour and the intestinal juice are the principal sources of these concretions, especially when they are formed upon an extraneous body which serves them as a nucleus.

ARTICLE XXIV.

Of some Abdominal Animal Matters peculiar to the Fœtus.

1. AMONG the peculiarities of structure and of functions which distinguish the fœtus from the adult, there exists three very remarkable differences relative to the abdomen. The fœtus in utero is immersed in a liquid inclosed in the amnios, which is called the *liquor amnii*; the suprerenal glands, very much developed, contain a liquor which fills their cavity; finally, the intestines of the fœtus present a liquid of a dark colour, which holds the place of the excrements, and which is called the *meconium*. These three humours, which have intimate and immediate relations with the life of the fœtus, as nothing similar to them is found even in the adult nor even in the infant some days or some months after its birth, merit the particular attention of the physiologist and the physician; they present to the first several problems relative to animal physics of great importance to be resolved, and to the second phenomena useful for the understanding of several diseases though chemistry has as yet afforded little light respecting each of them, it furnishes however some facts relative to their nature which ought not

not to be neglected. It may besides lead to discoveries the possibility of which we ought not to omit to mention, or to indicate their importance, and invite physicians to occupy themselves with them.

SECTION I.

Of the Liquor amnii.

2. THE amnios, the second membrane peculiar to the foetus, situated in the uterus below the chorion, much thinner than it, forms a kind of bag or sack, well closed at every part, the cavity of which contains the foetus immersed in a particular liquid. It is, if I may use the expression, the egg shell of the viviparous animals; it is thin and transparent; it is only with difficulty that we can perceive sanguineous vessels, in very small number and very minute, distributed in it. It is also very difficult to discern lymphatic vessels, of which however it is probable that its texture is formed, since it has besides all the characters, and performs the functions of a serous membrane. There is reason to believe that the membrane placed between the chorion and the amnios, which contains many vessels, is the source which furnishes the secretion of the liquor amnii. At the place where the umbilical chord, proceeding from the
4 placenta,

placenta, penetrates the amnios, it does not perforate it, but pushes it in some measure before it, and receives from it a doubling or kind of very thin sheath, which accompanies it to the navel of the foetus and quitting it at this region, confound itself with the integuments of the abdomen : thus the liquor of the amnios is contained and inclosed in a cavity comprehended between the internal surface of this membrane and the body of the foetus ; it even deposits upon the skin of the latter a mucous or flaky covering, more or less abundant, thick, whitish or yellowish, which it brings with it into the world, and from which it is generally freed by washing it off with warm water or wine.

3. The liquor of the amnios varies in quantity not only in the different individuals, the source infinite and inappreciable differences, but also in a constant manner at different periods of pregnancy and of the age of the foetus. In the first periods of pregnancy, it is much more abundant, comparatively with the weight of the foetus, and gradually diminishes till the period of delivery. Women however sometimes discharge a considerable quantity of it before delivery ; sometimes a large quantity flows off after the birth of the infant. It has been pretended that the liquor amnii is at first thick, sweet and mucous, and that it afterwards becomes limpid and acrid ; but it is possible that the effect of a morbid circumstance has here been taken for the natural state, and that such a change is effected

affected only by a pathological alteration. Some authors have announced in the water of the amnios a smell and colour similar to those of the urine : it is true that several anatomists have pretended that it proceeds from the urinary bladder of the fœtus, whilst others have considered it as the product of its sweat, its expectorations, or its digestion ; whereas it is very natural to believe that it has the same source as the liquid of all the serous membranes ; that it is a lymphatic exhalation and that it flows through the pores themselves of the sides of the amnios. No part of physiology has been the source of more romantic hypotheses than the origin and use of this liquid. In the great number of theories for explaining both the one and the other, we scarcely find a few facts respecting the properties and the nature of the water of the amnios ; and these facts are most frequently contradictory.

4. The liquor of the amnios is transparent, a little viscous and gluey to the touch, of a saline taste, slightly sweetish, so that it has been compared to whey by some authors, whilst others have asserted its similarity to urine. It is heavier than water, and first falls to the bottom of this liquid before it mixes with it. This liquid turns the syrup of violets green. Exposed to the fire it coagulates, not into a mass, but affords many clots or flakes that are soon deposited. The acids and alcohol produce the same effect upon the liquor of the amnios ; they coagulate it

it and produce in it a flaky precipitate. It is asserted that the coagulable property disappears in this liquor when it has become altered, when it has acquired an acrimony which sometimes is such as to corrode the hands of the accoucheur. The alkaline leys and lime water also produce a precipitate in this liquor, on account of the phosphoric salts which it holds in solution; the oxalic acid proves the presence of the phosphate of lime in it. The nitrates of mercury, of lead and of silver, also precipitate the liquor of the amnios, and the precipitate is a mixture of metallic muriate and phosphate. Tannin also forms in it a very abundant fawn-coloured precipitate.

5. Though the experiments of which I have just set forth the result, according to the facts collected by Haller in the works of Berbatius, of Ruysch, of Fanton, of Roederer, of Mauriceau, of Denys, of Sauvry, of Longfield, &c. are not sufficient to constitute a true analysis of the liquor of the amnios; they however exhibit very marked characters of an albuminous liquid; they show its similarity with the liquid which is exhaled in the cavities, and which belongs to the serous membranes; so that it is natural to compare it, as the most accurate physiologists have done, with the liquor of the pericardium, of the peritonæum and of all the lymphatico-serous membranes. Besides it follows their conditions; it shows their properties by its variable proportion, which is some-

sometimes such, that it resembles or even constitutes a drop, by the filaments and flakes which it deposits, and which adhere to the skin, as frequently takes place between the serous membranes and the surface of the viscera which they cover. This well marked analogy alone ought to induce us to believe that it is with the source of the liquor of the amnios as with that which lubricates all the membraneous cavities; that it is furnished by the arterial extremities proceeding either from the chorion, or from the cellular and vascular membrane situated in the middle between the chorion and the amnios.

6. An analysis of the liquor amnii of woman, made lately by Citizens Vauquelin and Buniver, Physician at Turin, confirms still more the first result of the ancient experiments. They have found it to have a sweetish and faint smell, like the spermatic liquor, a saline taste, a milky white colour, rendered turbid by flakes resembling cheese, which being retained upon a filtre, resembled the matter deposited upon the folds of the skin of the fœtus. Its specific gravity was 1,004; it became frothy like gum-water by agitation, turned the syrup of violets green, and yet reddened the tincture of turnsole; pot-ash precipitated gelatiniform flakes from it: the acids clarified it when it had become turbid by fermentation; alcohol separated from it a matter which became brittle by desiccation, like albumen. The gall-nut formed in it an abundant brownish deposition, as gelatin does.

Heated

Heated after its filtration, it became milky, without undergoing coagulation; it exhaled the smell of hard-boiled white of egg; it presented at its surface a pellicle which broke and was renewed; it gave a residuum weighing 0,012 of the liquor: this residuum washed with cold water afforded cubes of muriate of soda, and crystals of carbonate of soda; the animal matter exhaled upon the coals, a fetid ammoniacal odour, like horn; it left very little phosphate of lime. Inclosed in a bottle, it fermented, became turbid, and grew white, diffusing ammonia, without affording either odour or gas. The authors of this analysis have concluded that the water of the amnios is a solution very little charged with albumen, by means of a light and volatile acid containing muriate and carbonate of soda, and a small quantity of gelatin and of phosphate of lime.

7. The uses of the liquor of the amnios are manifestly to maintain the flexibility of the members of the foetus and of its coverings, to prevent adhesion between these parts, to guard the foetus against compression, to facilitate its passage by gradually dilating the neck of the womb, by softening and lubricating the parts through which it must pass: the discharge of this liquor generally indicates that delivery is at hand. As to the opinion of physiologists who add to these generally acknowledged uses, that of nourishing the foetus, though it cannot be denied that the liquor of the amnios may

perform this function, since it is generally sweet and albuminous; it is however much more probable that nature has not destined it for the nourishment of the fœtus, because it commonly has its mouth well closed, and the base of the tongue applied strongly against the velum palati; because it cannot perform real deglutition; and it is not proved that there is any liquor in its stomach similar to that of the amnios; and finally, because the small quantity of meconium contained in its intestines does not correspond with the mass of aliments which it might take in this way. The cases of the umbilical chord being withered, tied or destroyed, which seem to have authorized some authors to admit the opinion of the nourishment derived by the fœtus from the liquor of the amnios, cannot be favourable to this opinion, when their inaccuracy is examined: and those in which the fœtus has perished for want of this chord, or on account of its defects, are much more numerous and comparatively stronger. If, as some anatomists assert, there sometimes presents itself in the stomach of the fœtus a liquor which cannot be mistaken for any other than that of the amnios; this circumstance is so rare, and is besides involved in so many difficulties, that it ought to be considered as an extraordinary occurrence, actually contrary to nature, and in no respect favourable to the opinion which I endeavour to disprove.

8. Citi-

8. Citizens Vauquelin and Buniva, in the course of their inquiries concerning the water of the amnios of woman, have examined the matter deposited upon the skin of the fœtus, especially upon its groins, arm-pits and the hairy scalp. This caseiform substance is white, shining, soft to the touch, resembling new-made soap; it is insoluble in water, though it forms a froth with it when boiling. It is not attacked by alcohol or the oils. The alkalies dissolve it in part and convert it into a kind of soap; there remains a small quantity of undissolved mucilage. Placed upon the coals, it decrepitates and flies about like a salt; it dries, becomes black, exhales an oily empyreumatic vapour, and leaves an abundant coal difficult to be burned; treated in a crucible, this matter decrepitates, and exudes an oil from all its points, becomes horny, inflames, and affords a coal which is reduced into an effervescent cinder, composed of carbonate of soda and phosphate of lime. This analysis exhibits the matter deposited upon the skin of the fœtus, and proceeding from the liquor of the amnios as a sort of a tallow mixed with mucilage, or rather as an altered fat matter, almost adipocirous, analogous to the fat of burying-places, a kind of alteration which the entire fœtus frequently contracts after its death in the uterus, or in the tubes.

9. The water of the amnios of the cow, presented to the same chemists, characters very

different from those of the same liquor in the woman. It has a reddish colour, an acid and bitter taste, a smell of extract, a specific gravity equal to 1,098; it is viscous, ropy, and froths a like solution of gum; it reddens turnsol, precipitates the muriate of barites in abundance; alcohol separates from it abundant reddish flakes. When evaporated it becomes covered with an abundant scum, filled with white, brilliant, and four crystals; it is reduced into a thick viscous matter, of a fawn-yellow colour, analogous to honey. This residuum, treated with boiling alcohol, deposits from this solvent, when it has cooled, an acid crystallized in brilliant needles, several centimeters in length, and leaves undissolved a coloured extractive matter, of a pitchy or gluey consistence, from which the acid cannot be well separated except with a large quantity of boiling alcohol, employed at several times. These two principal substances of which the liquor amnii of the cow appears to be formed, and in which it differs from that of woman, have been examined with much attention, as new and particular matters, by Citizens Vauquelin and Buniva.

10. In order to obtain the acid of this liquor of the cow, it is necessary to reduce the liquor by evaporation to a fourth of its volume, and to let it cool. The acid crystallizes, soiled by a portion of extractive matter, which is separated by means of a small quantity of water, without touching the acid. When the water of

the amnios has given by evaporation and cooling, all the concrete acid that it is possible to extract from it; if we continue to evaporate it till it has acquired the consistence of a thick syrup, there are afterwards formed in it large prismatic crystals, transparent, bitter, very soluble, which are easily recognized to be sulphate of soda: it is sufficiently abundant; it is also extracted from the entire residuum of the liquor evaporated to dryness, after it has been burned, and by the lixiviation of its coal: it is then white and pure.

The amnic acid, extracted and purified by the process that has been indicated, is white, brilliant, slightly sour, reddens turnsol, is also soluble in cold water, but a little more soluble in boiling water, which deposits it in crystals by cooling. It swells upon ignited coals, turns black, exhales ammonia and Prussic acid, and leaves a pretty voluminous coal. The alkalies render it very soluble, and it is precipitated from them in a white crystalline powder by the acids. It does not decompose the alkaline carbonates unless by the aid of heat; it does not precipitate the earthy salts, nor the nitrates of mercury, of lead or of silver. It has some relations with the mucous or sacchatic and the uric acids; but it differs from the first in the circumstance that this, which is insoluble in alcohol, affords neither ammonia nor Prussic acid by the fire; and from the second, because this latter not crystallizing
like

like it, is insoluble in alcohol, becomes coloured in the air, and is reddened by the nitric acid.

11. As to the coloured extractiform matter which exists in the water of the amnios of the cow, it is, like the acid, of a particular nature. The following are the characters which the authors of this analysis have found in it. It is of red-brown colour, of a singular saline taste, of a strong smell analogous to that of evaporated urine, very soluble in water which it colours strongly, and insoluble in alcohol which separates it from the water. It affords by distillation ammonia, an empyreumatic oil and Prussic acid, like a true animal substance. Placed upon ignited coals, it swells much, diffuses at first a smell of burned bread, after which it exhales that of oil, of ammonia, and at last of Prussic acid; it inflames and leaves a voluminous coal, easy to be incinerated, the very white cinder of which is phosphate of magnesia; it gives to water a certain frothy viscosity; it does not assume the form of jelly nor does it unite with tannin. The nitric acid decomposes it and disengages from it azotic gas and carbonic acid gas, without converting it into acid. It differs in its properties from all other animal substances.

These facts relative to the water of the amnios of the cow, whilst they show a great difference between this liquid and that which exists in woman, prove how important it is to multiply

multiply the chemical examination of animal substances.

SECTION II.

Of the Superrenal Liquor.

12. IT is with the intention of omitting nothing that I speak of the superrenal liquor, rather than to describe its real nature, as nothing has yet been discovered relative to this subject. Indeed anatomists and physiologists are hardly well agreed whether there constantly exists a matter that deserves to be studied under this name. At least the learned Haller, after a very circumstantial description of the organ in which it is met with, still doubts whether there be really in this organ any peculiar humour? however, several professors of the art have allowed themselves to form hypotheses, and to propose theories respecting the superrenal liquor. Gaspar Bartholin considered it as the secretory organ of the atrabile, and the reservoir of this humour. Sylvius considered it as an acrid juice, which being mixed with the blood returning from the kidneys, served to dilute it and to render it irritating to the sides of the vena-cava. The illustrious Morgagni suspected that the superrenal liquor was destined to fill the reservoir and the thoracic duct in the foetus, whose intestines
cannot

cannot furnish this liquor. Some physiologists have even considered it as the seat of some of the passions. All this proves that the uses of this juice are yet altogether unknown; but as they appear to be of importance in the animal economy, both on account of the constancy and the magnitude of the glands which furnish it, and on account of its greater abundance in the foetus than in the adult, I thought I ought to make particular mention of it.

13. The superrenal glands, or capsules, in which this liquor is prepared, called also *atri-biliary glands*, are situated above the kidneys; and are larger than them in the foetus. They are oblong triangular bodies, flattened before and above, behind and beneath; and scooped out as it were at the surface, which rests upon the kidney; surrounded with much fat and cellular texture; terminated at their thin extremities by kinds of horns inclined inwards towards one another; receiving many arteries and veins; of a yellow colour; brown outwardly, more pale and reddish in the foetus, of a granulated texture similar to that of the conglomerate glands, and divided into a great number of globules. Within, the superrenal glands or capsules are of a deeper colour than externally; they are soft, and as it were spongy. They present an irregular cavity, very variable with respect to its size, the sides of which are frequently very near to each other, and as it were glued together by a cellular down; from the bottom, or the lower

lower side, a cellular prolongation raises itself resembling the comb of a cock, and adhering to the other sides by the same cellular texture with which these sides themselves are provided.

14. These very remarkable organs, which the anatomists carefully describe in faces, margins, angles, entirely unknown to the ancients, observed for the first time by Eustachius, and called by him *renal glands*, afterwards termed *succentri-
al glands* by Casserius, who believed them to be subservient to the secretion of the bile, described by Valsalva, Blasius, Morgagni, Harder, Peyer, Fanton, Tison, Perraut, Vallisnieri, Daubenton, in a great number of the mammalia and birds, diminish in size, without ever disappearing altogether, from the moment when the fœtus begins to respire. There is no doubt that the distension of the lungs, the pressure produced by the lowered diaphragm, the change of the form of the thorax which is enlarged towards the bottom, is the first cause, as it marks the first period of the diminution of these glands. The thymus diminishes in the same manner and totally disappears in consequence of the dilatation of the lungs. No excretory duct has ever been discovered in the superrenal glands, and it is not accurate to believe, with some anatomists, that the veins situated in the exterior ridge of these capsules are perforated laterally by a great number of holes, communicating with their interior cavity, for Haller and Cit. Sabatier have never been able to find these holes or this

com-

communication by injections ; Haller, however, asserts that air pushed through these veins in the mammalia, easily passes into their internal cavity. Thus the anatomical structure has hitherto afforded no light respecting the uses of these glands.

15. It is in the kind of capsule or interior cavity, and especially in the spongy texture adhering between its sides, that the superrenal liquor is found. In general it is only in small quantity, constantly more abundant in the foetus and infants than in adults, in whom generally only a few drops are found, and more frequently only a softish texture, slightly imbued with it, like a sponge, a little moistened. This humour is reddish in the foetus, yellow in the infant, and more or less brown in the adult. It appears to vary in its quality as well as in its quantity ; it has been indicated by some as sweet, by others as styptic, and by others again as insipid. Some physiologists have compared it to the blood; from which Haller however asserts it to be really different ; he assures us that he has seen it coagulated by alcohol. No chemist has yet examined this juice ; and it is rather imagination than experience that has attributed different characters to it, according to the different opinions formed of its uses. As no excretory duct is known, there is reason to believe that the superrenal humour is absorbed by the lymphatic vessels ; for the rest, it really remains a still unsolved problem, not only to know for what uses it

is destined, but even to demonstrate its existence as a determined and constant liquid; for no cavity has been found in the superrenal capsules of the squirrel, the bear, the sheep, the dog, the sow, the cat, the rat, the guinea-pig, &c.

SECTION III.

Of the Meconium.

16. THE meconium is a black, brown, or greenish-brown matter, of the consistence of liquid honey, or of a well-boiled syrup, ropy and viscid, contained in the intestines, especially the great intestines, of the foetus that has not yet respired, sometimes in considerable quantity, and existing in the duodenum, nay even in the stomach; which the infant generally discharges a few hours after birth. This liquid, which has usually been considered as the first excrement formed in the intestines of man, the origin of which is almost always referred to the bile, is most frequently without smell or taste; sometimes it presents a slight fetidity. Bordeu, the only physiologist who was well aware how interesting a subject the examination of the meconium would be, and who remarks that several anatomists have so far neglected it that they have
not

not even spoken of it in works otherwise sufficiently copious and well written, has paid much more attention to this subject than those who had preceded him. He has inserted in his medicinal analysis of the blood, an examination of the meconium, made by Bayen and Deleurye. It will be from that article that I shall give an account of this liquid.

17. Bordeu says, that he found the meconium generally inodorous, and sometimes of a disagreeable earthy smell ; it appeared to him to be not inflammable, more mucous than oily, having no predominant acid or alkaline character, being rather saponaceous, soluble in water and in alcohol, black in the large intestines, and greenish in the others. Without explaining himself farther upon its real nature and its origin, he however remarks, that the meconium is a sterco-ral matter which ought to be considered as the first essay of the work of the intestines. Hence he concludes that the viscera begin to exercise their functions already in the body of the mother. Though the foetus has tasted nothing, has swallowed nothing, though its animal functions have scarcely had time to unfold themselves, the intestinal tube, according to this physician, has begun to exert the action which it is destined to perform during the remainder of life. We shall see, in the researches of Bayen and Deleurye, a confirmation of this notion, and a result which renders the opinion founded upon it still more accurate.

18. At

18. At the instigation of Bordeu, Bayen made an analysis of the meconium which, though not very detailed, is at least sufficient to afford an idea of the general properties and the origin of that matter. This liquid analysed by Bayen, was of a deep olive colour, of the consistence of an electuary or a thickened mucilage, without smell and almost without taste ; it gave to linen a yellow tinge, which water could not take away, though it acquired a yellow colour. Diluted with sixteen times its weight of water to which it gave an intense yellow colour, there was precipitated from it more than half its quantity of a gross matter, which became brown by desiccation. Heated in an iron spoon, it swelled, diffused a vapour at first aqueous, afterwards oily, always of a less disagreeable smell than that of the other animal substances ; it did not inflame though the spoon was heated to redness. Dried in the water-bath, it lost more than $\frac{4}{5}$ of its weight, and presented a brown opaque mass, easy to be pulverized, and exhaling a sweet agreeable odour, analogous to that of inspissated milk ; it was a little bitter. A small portion of this dried meconium put to digest with ten times its weight of alcohol, gave it a deep yellow colour ; this liquor being evaporated left a tenth of its weight of a matter, yellow like saffron, transparent, bitter, and in every respect similar to that which is extracted from the bile by the same re-agent. The residue of meconium not dissolved by the alcohol was black, though susceptible

ceptible of giving a yellow colour to water. The greater portion of the dried meconium, heated in a small glass retort, gave half its weight of water, about a twelfth of oil, carbonate of ammonia, and an elastic fluid, which Bayen then considered to be air. There remained a coal forming a sixth of the mass, which still presented ammonia by roasting, became incinerated at its surface and hard at its centre, after having been kept red-hot for five or six minutes, as the coal of every animal matter does. A longer roasting rendered it friable, though it remained black; it had lost a little less than half its weight, and effervesced with the nitric acid. Bayen concluded from these experiments, that the meconium was not a real excrement, but a milky excrement, already mixed with the bile, as those of adults were.

19. Borden then gives some observations of De-leurye upon the meconium; they tend to ascertain points opposite to those of Bayen, as they indicate a fetid smell, both in this liquid heated alone, and in the same juice heated with water. The same practitioner remarks that in several infants that died in their birth, from which he had procured the meconium, he found that the gall-bladder contained a liquid inclining more to red than to the colour of the bile; in fœtuses that had died before having respired, he found no liquid in the stomach, but only a gluey reddish lining, as was that of the small intestines; a white and thick lining in the cœcum :
and

and a still thicker one, but brown and resembling the meconium, in the colon, especially the nearer it approached to the rectum. The internal surface of the colon, according to this practitioner, was spotted with the brown tinge of the meconium, and very difficult to be cleaned; the rectum was full of viscid meconium, difficult to be removed, and it obstinately retained the colour of this excrementious liquid.

20. These parts were sufficient to induce Bordeu to consider the meconium as the purest part of the bile, accumulated in the liver, turning black in proportion as it loses water, giving a yellow tinge to the membranes to which it adheres, sending particular emanations into the surrounding parts, mixed with mucous, stomachic and pancreatic humours, forming a column of matter upon which the intestines mould themselves, and from which they derive their form. He mentions the case of an infant who had died in consequence of a vomiting of meconium which he had discharged by the anus, and in whom the left part of the colon was found contracted like a cord. It is natural to think, according to him, that some of the emanations of the meconium pass into the lacteal veins, and from thence into the blood; he finds in it even the source of the colour of the blood, originally developed in the liver, as well as a certain analogy between this colouring matter and the blackish humour
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of the succentrial reins. He endeavours to follow this colouring part of the blood in the revolutions of the several ages till the period of old age, especially in the bilious temperaments; he observes it forming the colour of the abdominal blood; he compares and recognizes it in the attrabile or the melancholy of the ancients, denied in vain by the moderns; he announces its cachexy in the *meloena* or *morbus niger* in the jaundice of new born infants, which frequently goes as far as black jaundice; in the mucous texture of the negroes who are born white and grow black only in course of time; he believes it admitted even in the black hairs to which it gives colour, in the eye the sclerotica of which it tinges with its dark pigmentum, or animal ethiops. I must not pursue these views farther, though they undoubtedly are ingenious, but too far remote from the path of experiment, and too nearly approaching to the hazarded assertions of medical theory to deserve the confidence of chemists. New researches must enable us to determine how much reality there may be in these notions: the object is well worthy of all the zeal and industry of those physiologists who knowing the utility of chemistry, may find themselves in circumstances favourable to the success of those useful investigations.

ARTICLE XXV.

Of the Urine.

1. THE urine of man is one of the animal matters that have been the most examined by chemists, and of which the examination has at the same time furnished the most singular discoveries to chemistry, and the most useful applications to physiology, as well as the art of healing. This liquid, which commonly inspires men only with contempt and disgust, which is generally ranked amongst vile and repulsive matters, has become, in the hands of the chemists, a source of important discoveries, and is an object in the history of which we find the most singular disparity between the ideas which are generally formed of it in the world, and the valuable notion which the study of it affords to the physiologist, the physician, and the philosopher. The numerous and important facts which its history comprehends, and the necessity of presenting them in a methodical manner, induce me to divide this article into ten paragraphs. The object of the first will be the natural history or the formation of the urine; of the second, the knowledge of the physical properties which characterize this liquid; of the third,

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third, the exposition of the principal discoveries to which it has given rise; of the fourth, the examination of its chemical properties; of the fifth, that of the different materials which are extracted from it by analysis; and which constitute it by their simultaneous solution in water; in the sixth, I shall particularly consider an urinary substance which belongs only to this liquid, and gives it its true characteristic properties; in the seventh, I shall describe the varieties which the urine presents in different circumstances of human life; in the eighth, that which it presents in the different animals; finally, the ninth paragraph shall be employed in shewing the influence which the discovery of the materials of the urine must have upon the progress of human physiology; and the tenth, in announcing the very numerous uses for which urine is employed, both in medicine and in the arts.

SECTION I.

Natural History or Formation of the Urine.

2. THE kidneys, the venal or emulgent arteries and veins which are distributed in them, the ureters which proceed from them, the bladder into which the former open, and which is terminated by the canal of the urethra: these comprehend the whole apparatus which nature employs for separating the urine and evacuating it out of the human body. The kidneys, surrounded with a great abundance of fat, and situated on the outside of the peritoneum, in the posterior part of the abdominal cavity, composed of a very dense fleshy texture, granulated when torn, and itself formed of a great quantity of convoluted vessels, receive an abundant mass of blood, proceeding immediately from the aorta, and still possessing a considerable velocity, though the renal or emulgent arteries go out from it at a right angle, a position which retards its motion. It is commonly believed that the urine comes immediately from the blood, and that the water which constitutes its greater part was ready formed in the latter liquid. It is however possible that this water might be formed in the

secretory organ itself, at the expense of the decomposition of the blood; but the decision of this important question requires observations and experiments made purposely and in an order relative to these researches. Anatomists describe three different substances in the texture of the kidneys; the external or the cortical, which is the thinnest, the most dense and most coloured, the middle or the tubulous, and the interior or the papillary. The first separates the urine; the two others conduct it into between eight and twelve cups or funnels which receive the extremities of the papillae, and which open into a membranous cavity called the *pelvis*.

3. This membranous bag or basin, placed in the hollow of each kidney, under the vessels, and supported upon the interior and posterior layer of these viscera, gradually receives the urine running from the papillae into the calices, and conveyed by the latter. In proportion as it arrives in the *pelvis* formed by a dense membrane, it descends by a duct extending obliquely on each side from the kidneys to the bladder, and traversing the posterior part of the abdomen, the bottom of the *pelvis*, to open into the lower and posterior region of the urinary bladder. This double canal, which is called *urether*, is of the thickness of a moderate sized quill, flattened as it were, and formed of a single membrane, which is very hard, little susceptible of dilatation in the sound state,

neither

ther muscular nor irritable, performing the action of a simple tube, or of a long funnel, in which the urine is never detained. Those rare cases, in which there is only one ureter, situated upon the middle of the spinal column, two ureters are generally found; which proves that these are two kidneys close together, and with their substance intermingled; sometimes there exist three kidneys, which are each provided with three ureters.

The bladder, situated behind the pubis, in the small pelvis, projecting after infancy a little above these bones, nearly of the form of a truncated cone, with its base downwards, is composed of two principal membranes, the muscular, which is pretty strong and irregular in the direction of its fibres, which are condensed and accumulated; especially towards the bottom; the other, cellular or villous, folded inwards, sometimes even forming a kind of projecting columns, and particular cavities or little bags. The bladder is retained in its place by a very abundant cellular texture condensed by ligaments towards the inferior, superior and posterior parts; it presents towards the summit a depressed part, which is called its *fundus*; in its interior it exhibits, between the two oblique orifices of the ureters and the origin of the urethra, a projecting triangular fold, and a circle towards the urethral orifice; it is more contracted in the fœtus, and it has towards the perineum a duct called *urachus*; it is widened into

into the form of a barrel in pregnant women and is then detached from the peritonæum which in the ordinary state covers its fundus; it receives the urine, which is continually poured into it, in small uninterrupted streams, intermittent however with respect to the quantity and velocity. The capacity of the bladder amounts to several litres, and varies greatly. The urethra, or the canal that terminates the bladder, which proceeds outwards, and forms a part of the penis in men, opens at the upper part of the vagina with women, below the clitoris and between the nymphæ, affords a passage to the urine, and evacuates it out of the body.

5. When the urine has remained for some time in the bladder, which is distended by it, and especially when it is very abundant, it irritates the fibres of this organ, produces an urgent desire, and is discharged by the pressure which the will produces upon the sides of the bladder; it is evacuated in a more or less rapid stream, according to the acrimony and the quantity of the urine, according to the sensibility of the bladder, and the energy of its fibres: a too great distension frequently causes it to lose its contractile force, on which account it is always dangerous to resist the inclination to void the urine, and not to satisfy it as soon as it is felt. When the urine passes through the canal of the urethra, and is discharged in a continued stream, it frequently excites a more or less irritating and hot sensation, sometimes

even acrid and burning, when it is too much charged with its principles, and commonly when we have drank too much of spirituous liquors, or used too violent exercise. The slightest morbid irritation in the canal of the urethra renders it also excessively sensible, and changes into pain the evacuation of the urine, which in the natural state of perfect health is attended with no particular sensation, and escapes almost without its passage through this canal being perceived.

6. Two and even three species of urine are distinguished, according to the times at which it is voided : the first is called the urine of the drink, or crude urine ; the second the urine of digestion, or of the chyle ; the third, the urine of the blood.

The first is called the urine of the drink, because it is voided immediately after a meal. This is not even real urine ; it has generally neither the same smell, colour, nor weight ; it contains very little matter in solution, and it is not this liquor that we ought to examine, in order to ascertain the nature of the urine ; it is sometimes discharged in considerable quantity.

Urine of digestion, or of the chyle, is that which is discharged two or three hours after a meal, and which is distinguished by a more intense colour than the first, as well as by the smell, and even the taste of the aliments that have been taken : this is not yet perfect urine,

or

or that which ought to be chosen for experiments intended to ascertain the real principles of this excrementitious liquid.

7. Seven or eight hours after a meal, and especially in the morning when the person has slept for several hours after supper, there is discharged a coloured, acrid, sapid, and highly odorous urine, not presenting the characters of the aliments that have been taken, but of a particular odour which is peculiar to it; in a word, a well constituted urine, enjoying all the properties that appertain to it. The circumstances of digestion, the nature of the aliments, exist no sensible influence, or at least a much less influence, upon this: and for this reason it has been called the urine of the blood. When we choose this genuine urine, voided by an adult, healthy and vigorous subject, and examine it immediately after it has been discharged, and especially without waiting till it has undergone the spontaneous alteration of which it is susceptible, as I shall show hereafter, we find in it all the characters which distinguish this kind of excrementitious liquid: it is also this urine of coction, this urine perfected by nature, which remains for the least space of time in the bladder, which produces the most urgent inclination to void it, and which cannot be retained without much greater danger than the two preceding kinds.

8. The large quantity of urine which frequently is voided a very few moments after drinking;

drinking; and the rapidity with which an odorous substance brought in contact only with the skin or lungs is transmitted into this liquid, have rendered it doubtful whether it always goes through the medium of the circulation, and have led to the belief that there exists another passage for the transmission of liquids. It has been imagined, that water impregnated with different substances might filtrate into the bladder without passing through the kidneys; and though no duct, except the ureters, has been found that opens into the reservoirs, several physiologists have believed that such exist, or have, and that the lymphatic vessels perform these functions. However this may be, it is certain that there exists a reciprocity, a correspondence of action, a very remarkable sympathy of effect between the skin and the bladder, or the kidneys, or to speak more accurately, between the transpiration and the urine; that when the first is very abundant, the second is diminished; that when the transpiration is stopped, the flow of the urine is augmented, and that there seems to exist a kind of regurgitation between these two humours. Circumstances also occur, in which the transpiration presents the properties of the urine, though in a much inferior degree, yet in a sufficiently perceptible manner to prove a striking analogy between these two excretions. The most able modern physiologists simply explain this reciprocity of effects between the discharge
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by transpiration, and that by the urine, by the general repletion of the vascular system, which communicates itself easily and pretty rapidly from one contiguous part to another.

9. We may also perceive a sympathy between the stomach and the organs destined for the secretion of the urine: a multitude of alimentary substances and drinks transmit from the interior of the stomach, into which they have been received, more or less sensible properties to the urine, within a few minutes after they have been introduced into it. This phenomenon is very perceptible, especially with persons of delicate and sensible habits of body with whom digestion is frequently laborious and feeble: we may distinguish the nature and characters of the aliments which they have just taken by the smell of their urine. This not only holds good with respect to substances which are naturally very odorous, such as garlic, onions, asparagus, the aromatics, the balsams and perfumes, but also with respect to those that have only a very slight, and sometimes scarcely perceptible smell. I have observed, as Macquer had indicated, that the urine of hysterical women and hypochondriacal men, voided immediately after meals, had the smell of the bread, the soup, and the meat which they had eaten. It does not appear to be necessary, in order to explain this phenomenon, to admit vessels communicating from the stomach to the kidneys, or even the bladder, the existence of

which is rejected by the most able and accurate anatomists. The lymphatic system is adequate to perform this function, which ought not to be attributed to a particular glandular apparatus.

10. The case is the same with the relation to the re-action which exist between the evacuation of the urine and the functions of the intestines. It is frequently observed, that abundant liquids, which for some time distend the intestinal tube, pass off by urine, of which they produce a considerable discharge, and that, on the other hand, the urinary matter when detained in its secretories, and unable to pass off by the ureters, procures itself a vent through the intestines, when it is evacuated in the form of a serous diarrhoea. Glysters injected by the anus very frequently pass into the bladder: the absorbent vessels, which exist in great quantity in all these organs, establish a prompt and easy communication between them. We also observe the same circumstance with respect to the abdominal cavity in which the hydropic water is accumulated: frequently this liquid is evacuated by the urethra, and there is no reason to believe that it has passed through the kidneys. As it is sometimes conducted by the absorbent vessels into the intestinal canal, there is no reason why it should not be conducted in the same manner into the bladder, which also receives many of these vessels at its surface.

SECTION II.

Physical Properties of the Urine.

11. WE have seen that there may be discharged, and that actually there is frequently discharged by the urethra a liquid which has not the true characters of urine, though this name is constantly given to every liquid that passes off in this way; that it is only several hours, seven or eight, after meals that the true urine is evacuated; that the other liquids either do not enjoy its properties, or present them only in a very slight degree. Accordingly, it is only that urine, the discharge of which is subsequent to the complete digestion of the aliments, and the mixture of the chyle with the blood, which must be examined in order to ascertain its characters. We must choose such as has been voided by a healthy adult after waking in the morning: in this case it has all the properties that belong to it. The urines of drink or of meals, as well as those of hysteric diseases or attacks, and those which accompany grief, fear, and the depressing passions in general, form exceptions and modifications of this liquid, more or less remote from the natural state, and presenting results more or less different.

12. The

12. The quantity of the urine, as must be conceived from what I have already said respecting its formation, varies in almost infinite degrees; physiologists therefore have been much embarrassed to determine it. Haller, who devotes one of the paragraphs of his *Physiology* to this calculation, begins with affirming that he cannot define it in the healthy subject; it singularly follows the quantity of the transpiration, with which it is almost exactly in an inverse ratio; it exceeds the transpiration in the proportion of 3 to 1 in the cold and wet months; in the hot and dry season it is less abundant than it. In the intermediate state of the atmosphere its quantity is equal to that of the humour evacuated by the skin: it is generally more abundant with old persons, whose skin is more dense, and loses less; in youth, the transpiration is to the urine as 1340 to 1000; in old age, on the contrary, it is as 967 to 1000. In bed, the urine is to the transpiration as 4 to 3. Such is the result of the experiments and calculations of Robinson, as admitted with confidence by Haller.

The proportion of the drink has much influence upon that of the urine, as we observe in sick persons and those who take the mineral waters; Dodart estimated its quantity to be equal to that of the liquids received; Cheyne estimated it only at three quarters; from a comparison of the researches of Sanctorius, Keil, Robinson, Gorter, Rye, Home, Dodart, Linings,

Linings and Cheyne, Haller gives for the various quantities of urine voided in twenty-four hours, the sums of 28, 31, 36, 38, 40, 44, 50, and even 64 ounces, the mean term of which quantities is 49. Nothing accurate can be established upon these results, which prove that the proportion of the urine is extremely variable.

13. Though we may to a certain point admit the same variation in all the physical properties of this liquid, we find however more constancy and stability in most of them. One of the most marked and most certain characters of the urine is its colour; no animal liquid presents a similar one, and it is exclusively given to it by nature. This colour, which varies in its intensity from a lemon yellow to a deep orange, is owing to a particular matter, the relative proportion of which to the water, produces all the possible tinges that are known. Bellini, who occupied himself much with urine, in a medicinal point of view, understood this fact respecting its colouration; he asserted that the urines differ in their most dissimilar colours, from the palest to the most intense, only from the relative quantity of water: so that, according to the observation of Boerhaave, which is only a consequence or inference from the opinion of Bellini, we can produce from the most intensely coloured urine, all the intermediate tinges to the very palest, and thus imitate the process of nature; nothing

nothing more being required than to add different quantities of water. It however must be remarked, that the lemon or slightly orange colour, joined with perfect transparency and limpidity, which announce a liquidity very homogenous in all its parts, is the true characteristic and natural tinge of the urine of a healthy person. I do not here speak of the varied colours which the urine affects under certain pathological circumstances, of the red and inflammatory urine, of the saffron coloured urine, of the black urine of melancholic affections, of the green urine of patients labouring under jaundice, of the blue urine observed in some cases of stranguary. These different colours indicate deviations from the healthy state.

14. The smell of the urine is also a property which belongs exclusively to it, and has not yet sufficiently engaged the attention of physiologists. Immediately after it has been discharged, the urine, while still hot, has a smell which is truly aromatic, has nothing fetid, or ammoniacal or acid, and resembles nothing else, but is so well characterized that no other natural substance can be confounded with it: that which approaches the nearest to it is the odour of the violet; but the smell of the urine is stronger, more pungent and more exalted; it is never alkaline or ammoniacal unless when the urine has suffered a commencement of alteration: accordingly, when ammonia is characterized by the expression of an urinous smell,

smell, this ought to be understood only of urine already putrefied. It is very remarkable that the smell which most resembles that of fresh, healthy and warm urine, is the aroma of the transpiration, which is discharged in the fluid state by healthy persons; we find it also in the perspiration of the horse when undergoing violent exercise. We shall hereafter see that this depends upon the presence of a matter peculiar to the urine, and which exists sometimes, perhaps even always, but only in small quantity, in the humour of the transpiration and moisture of the skin.

15. The urine, when discharged from the bladder, has a temperature equal to that of the internal part of the body, namely from 29 to 32 degrees, according to the thermometrical scale that marks 80 or 85 for ebullition: this gives $36\frac{1}{4}$ for the centigrade thermometer. It exhales into the air a portion of odorous water as long as it preserves its heat: this water is in the state of a visible fume when the air of the atmosphere is at 5 degrees $\times 0$ and moist; it is perceptible only by its odour when the atmosphere exceeds 10 degrees $\times 0$. It is asserted that, in some diseases, the urine has a more elevated temperature, which is difficult to be believed according to the known laws of the animal economy; it is even almost impossible that its temperature should be lower. In proportion as it loses the elevation of its temperature, it likewise loses its aromatic smell. Sometimes

times it becomes turbid by mere cooling, either in consequence of its own highly charged state, as in the crises of diseases, or in winter when it is cooled in a very considerable degree, or in the summer after a violent storm. We shall hereafter explain the cause of this precipitation.

16. The fluidity of the urine, though at first sight resembling that of water, presents however, when considered with attention, a sensible difference. We soon perceive an adhesion between its particles somewhat superior to that which exists between those of the aqueous fluid; though it is much less strong than is observed in the serum of the blood, the saliva, and especially the bile, which is always ropy. However slight it may be in the natural and healthy state, we see at least that it is very much disposed to become in a very short time more considerable, in consequence of the slightest change that may take place in this humour, either with respect to its own composition, or with relation to the bladder in which it is accumulated and detained. With infants, it is mucous, and slightly adhesive. In all the diseases in which the patient wastes away, and especially in phthical cases, it becomes mucilaginous and gluey. In the calculous affections, and whenever the bladder is irritated, the urine acquires so viscid a character that we see it filled with semi-concrete flakes and

filaments. The different degrees of consistence and viscosity which it frequently acquires from slight causes, depend upon a gelatinous mucilage, the proportion of which is susceptible of a great number of variations, but which is always contained in it, as I shall show in the subsequent paragraphs.

17. The specific gravity of the urine is also a variable character. Some physiologists have erroneously asserted that it is lighter than water: it is constantly heavier, but its increase of density has something singular in it, when we know that it contains a considerable quantity of substances in solution. We are led to believe from this property alone, that the materials which constitute it, are themselves rather light bodies: we shall see hereafter how much foundation there is for this notion. Silberling, in his Treatise on the specific gravity of the animal humours, estimates that of the urine with respect to water, as 271 to 261; Hamberger, as $399\frac{1}{4}$ to 388; Davies, as 1080 to 1000. Bryan Robinson asserts that, in middle age, its weight is to that of water, as 10300 to 10000, and with old persons, as 10218 to 10000; Muschenbrœck gives its proportion as 1030, water being 1016. Brissot, in his Table of the specific gravities of bodies, finds it 10106. It has been observed, that when the density or specific weight of this excremental liquid increased, and continued for some time in its augmenta-

tion, it was a dangerous symptom for the health of the individuals in whom it presented itself.

18. The taste of the urine is pungent, saline, a little acrid, and slightly bitter. As this property varies in a multitude of cases according to the state of diseases, anatomists and physicians have observed in it various acrimonies, which they have described as pathological signs or characters. The saline or marine acrimony, which is the most frequent of all, and is constantly found in this liquid, has been attributed to the presence of muriate of soda; it is from this kind of acrimony that the sensation of thirst seems to proceed, which is excited by urine used as drink, either in cases of urgent necessity, or for medicinal purposes. Holwell, when confined in the black-hole at Calcutta, found the thirst, with which he was cruelly tormented, greatly relieved by swallowing his perspiration; but it was impossible for him to drink his urine. The chief reason why this saline acrimony has been admitted is that the first chemists who examined the salts of the urine, Van Helmont, Henckel, Tacheneus, Boyle, Pohnius, Neumann and Spielman, constantly found the muriate of soda in this liquid, and considered it as the most abundant saline principle of the urine.

19. The alkaline acrimony of the urine, that is to say the circumstance in which the urine is alkaline, never takes place in the healthy state.

It is met with only in cases where the urine has already been altered in its reservoirs, as it happens when out of the body. But as it is actually very much disposed to contract this character, it happens frequently that it exhibits it in diseases, especially in those in which it is detained, for a more or less considerable time in the bladder. After some hours, this alkalescence develops itself in the urine; it then turns the blue vegetable colours green, and even proceeds so far as to produce effervescence with the acids. It is on this account that it becomes useful in fulling, that it easily takes off the greasy impregnation from the fleece of the sheep, and that it afterwards lathers with water. However we must not confound this acquired acrimony, to which the urine is indeed very much disposed, with its natural state which presents nothing of the kind.

20. As to the acid acrimony, it is that which may be admitted with the greatest utility and truth, because healthy urine is naturally sour. It is true, that this sourness is so slight, that it is difficult to perceive it, even when we taste urine with much attention. Nevertheless the sour smell of urine has been described. Vieussens and Mariotte have asserted that urine reddened several blue vegetable colours; that this acidity was lost in the course of time, and that it passed into the ammoniacal state. We shall hereafter see the cause of this change, which actually takes place. Several physiologists have maintained that the urine is neither acid nor alkaline, and this is the opinion

opinion which Haller supported : he attributed the acidity of the urine, which in fact is so slight as to redden only the most delicate blue vegetable colours, to the drink that may have been used and especially to rhenish wine ; but the urine is acid with individuals who drink no wine, so that it is impossible to conclude that its acidity proceeds from this liquor, and we may assert that the natural acrimony of the urine is acid.

SECTION III.

Historical Sketch of the Chemical Discoveries made upon Urine.

21. I HAVE already observed that the urine has been the subject of numerous and important researches, and has afforded occasion to chemists for making many discoveries. I shall here point out the principal epochas of those discoveries and their authors. But I shall omit the mention of the writers who have occupied themselves with it only under a medicinal point of view, because these kind of researches, which are useful when severe and accurate observation presides over them, have been tarnished in their lustre by the hypotheses with which they have been loaded ; they have been disgraced by the absurd pretensions of uroscopes and uromancy ;

of the chemical knowledge of his times to physiology and the art of healing.

26. Boerhaave has given, in his *Elements of Chemistry*, nine processes upon the properties and the analysis of urine: and he, amongst all the medical chemists from the commencement of the eighteenth century, has added the most to the first essays of Boyle upon this excremental liquid; for Stahl is remarkable in this part of the history of the science only by the singular obstinacy with which he maintained that it was the marine salt contained in urine which yielded the phosphorus, and that the muriatic acid was to this combustible body what the sulphuric was to sulphur; an error with which several writers have justly reproached him, and which forms a blot in his works, otherwise so commendable for the clearness and method which pervade them. In his nine processes, Boerhaave endeavoured to prove that the urine was neither acid nor alkaline, that it afforded no alcohol, but a fetid principle analogous to that of the sweat, and a putrid oil; that it contained nothing chylous, nutritious or coagulable by fire, but only acrid, putrid attenuated matters, dangerous to health, that after the horribly fetid oil which is extracted from it by distillation, there remained a coal from which muriate of soda but no fixed salt might be extracted; that fixed alkali and lime disengaged from it an acrid matter, a kind of vapour dangerous by its action upon the body; that the
urine

that Van Helmont had a better insight into the nature of the human urine than all his predecessors. But these rays of light, enveloped in a mass of obscurities and extravagancies, escaped his age; besides which he has not described one experiment, nor even indicated one positive fact, in support of his truly unheard of conceptions, as he himself denominated them.

23. It is to Boyle only, towards the end of the seventeenth century, that the first chemical experiments made upon the human urine are to be traced. The discovery of phosphorus, made it 1796, by Brandt, of Hamburgh, who operated upon the urine with alchemical views; the labours of Kunckel, who succeeded in preparing it with the residuum of the evaporation of this animal liquid, gave, as it appears, to Boyle, the inclination to make a subsequent examination of this liquid, and he deposited in 1680, at the Royal Society of London, a small piece of phosphorus which he had extracted. He communicated his process to Hawkwitz, a druggist of London, who occupied himself during several years with this originally urinary preparation, and sold phosphorus for more than twenty years to all the philosophers of Europe. We see that it is to this combustible body, which was long called phosphorus of urine, that we owe the first series of chemical experiments that has been undertaken upon this liquid. For I can scarcely reckon amongst these experiments the employment of urine for the different processes of fulling woollen

this might be extracted from the residue of the distillation of the phosphorus of urine by lixiviating it; that the muriate of soda never afforded phosphorus, notwithstanding the assertion of Stahl. He discovered that by distilling the calcined extract of urine with muriate of lead, phosphorus was obtained from it; and as the successive labours of Schloffer, of Haupt and of Klaproth upon the fusible salts of the urine, have exhibited the two phosphates, we see that Margraff, without knowing that of soda, had found the means of decomposing it by the muriate of lead. We here again perceive the influence which the enquiries relative to the extraction of phosphorus have constantly had upon the analysis of the urine, and how much they have contributed to the determination of its saline materials.

28. It is in the same order of experiments upon the urinary salts and upon the nature of the phosphates that we must rank the fine dissertation of Pott upon the *fusible salt* of the urine, or the *microcosmic salt*, published in 1757; the dissertations of Haupt, of Schloffer, of Schockwitz, of Proust, of Bergman upon the different saline substances which it contains; the experiments of Chaulnes upon the purification of this salt; finally, the much more complete and much more important labours of Rouelle the younger upon the analysis of the urine. This able analyst, of whom I have so often had occasion to speak, gave in November, 1773, in the

the *Journal de Medicine*, some valuable observations upon the comparative analysis of the urine of man, of the cow and of the horse. He first announced a saponaceous matter, crystallizable, deliquescent, soluble in alcohol, affording more than half its weight of volatile alkali by distillation. He indicated the great chemical difference existing between the urine of the drink and that of digestion, and that which distinguishes putrid from fresh urine: he discovered that the urines of the cow and the horse, being without phosphoric salts, contain a saponaceous matter like that of man, with chalk which separates from it by cooling, and benzoic acid. He likewise announced the several different salts which exist in each of these urines, and the art of separating them from one another; he found the sulphate of soda in the human urine, and the sulphate of lime in that of the horse.

In July, 1776, he inserted in the same journal some very well made experiments upon the phosphates of ammonia and of soda, to the first of which he gave the name of *fusible salt*, with base of volatile alkali, and to the second that of fusible salt with base of soda; and he described the means of separating and distinguishing them, as well as several remarkable phenomena of their purification and their specific properties.

Lastly, in April 1777, he inserted in the journal de medicine some observations upon the
urine

researches upon the urine in which we have been engaged for several years past, we perceived long before the English chemist whom I have mentioned, this extremely characteristic property of this substance; we have been examining it by a great number of chemical experiments, when subjected to many experiments and observations, it became to us a subject of considerable discoveries respecting the properties of urine, and of important applications to medicine and physics. It will also appear that the farther researches upon the human urine have enabled us to discover in it some saline substances which were not known to exist in it before, and especially to determine the extraneous changes, which several of the materials of urine undergo, during the fermentative process, of which it is so quickly and so susceptible. These changes well applied have also conducted us to the knowledge of what takes place in the formation of the urinary calculi, and enlightened us respecting the nature of these calculi and the means of attacking them in the bladder.

SECTION IV.

Account of the Chemical Properties of the Human Urine, and of its Analysis.

31. IN the considerable series of experiments that have been made upon the human urine, most of the means which chemistry presents for determining its nature and ascertaining its principles, have been exhausted. The action of different temperatures, evaporation carried to more or less extent, refrigeration succeeding evaporation, congelation, distillation on the water-bath, and by the retort, have furnished many useful processes. Exposure to the air, spontaneous alteration, fermentation, and slow evaporation have been employed with equal success. The mixture of a great number of re-agents; the action of water, of the acids, of the earthy and alkaline bases, of the salts, of the metals and metallic solutions, have also thrown light upon the chemical properties of urine and its component parts. Lastly, it has been placed in contact with different vegetable substances, especially the colouring matters, alcohol, and tannin; and researches of this kind have even been carried so far as to examine it by different animal substances. As none of the

effects which it presents by these different modes of treatment is unimportant with respect to the knowledge of its properties, I shall here give the result of all the phenomena to the discovery of which they have led.

32. When fresh urine is heated in open vessels by a mild heat and without making it boil, water is disengaged with a urinous but not fetid odour; the colour of the liquid becomes more intense and changes to a bright red; it soon becomes turbid and deposits a whitish or slightly coloured powder, with some coagulated flakes similar to the albumen. The smell, which at first was aromatic, soon changes to an ammoniacal odour, though the liquid be not heated to ebullition; this ammoniacal smell has at the same time something acrid and pungent. The urine, which in its natural state always reddens turnsole, no longer reddens it at this period, but on the contrary it turns paper blue that has been reddened by an acid, a proof that it then contains an excess of ammonia, which is formed in it by the action of the fire. In the progress of this operation, by which we may reduce it to different degrees of consistence, and even to dryness, the urine passes from red to a brown colour; and if, when it is of the consistence of a thin syrup, we place it in a cool and quiet situation; a large quantity of brown or impure crystals are formed, which have been called, *fusible or microcosmic salt, native salt of urine*. The liquor being decanted off, it is

better from the phosphate. He followed the same process in order to obtain the last portions of salt from the mother-waters: three or four years of spontaneous evaporation were scarcely sufficient to exhaust them of this salt. He also evaporated the urine to a consistence thicker than that of a syrup; he then placed it upon a cloth, washed the marine salt that was left upon the filtre, added this lixivium to the matter which he also diluted with water in order to prevent its crystallizing and to render it more liquid than a syrup; he added carbonate of ammonia to it, then evaporated it again by fire, and by afterwards exposing it to the air, he obtained abundance of fusible salt. He also recommended the precaution not to subject this concentrated liquor to spontaneous evaporation except in fine weather, but to keep it in the winter in well-closed vessels, in order to prevent its absorbing humidity.

35. The purification of the fusible or native salt, formed of the phosphates of ammonia and of soda and of muriate of soda, was also formerly one of the principal operations that were performed upon the urine. Margraff occupied himself much with it in 1743, Pott in 1757, Schlosser in 1760, Haupt in 1740, Chaulnes in 1773, and Rouelle the younger in 1776. I shall present to the reader the observations of the last-mentioned chemist, which contain what is of the most importance and the greatest utility to be known respecting this subject. This able chemist

chemist, considering, like all the authors who had preceded him, the phosphate of ammonia as the true fusible salt, because he well knew that this alone affords phosphorus in its distillation with charcoal, begins with observing, that this salt, when extracted from the urine by the foregoing processes, is very impure and mixed with a saponaceous brown matter which he calls *soapy*, with muriate of soda, and with another salt affording voluminous and efflorescent crystals: this is the phosphate of soda which before him had been taken for sulphate of soda. By dissolving this impure fusible salt, composed, as we see, of four different substances, in five or six parts of slightly heated water, and after filtration through paper, by evaporating the solution, there is first disengaged ammonia and entire fusible salt, which attaches itself in white points and in a crust to the empty part of the basin, and even upon the furnace which sustains it. Rouelle attributes to the water and to the ammonia, this elevation of phosphate of ammonia, which, he asserts, is deprived of its volatile alkali, because, according to him, it produces an effervescence, with the liquor which contains an excess of it, and with a solution of carbonate of ammonia when applied to it with a straw. The liquor must not be evaporated to the formation of a pellicle; it afterwards affords by cooling, and especially by spontaneous evaporation in the air, the phosphate of ammonia which crystallizes first; above this
larger

larger crystals of phosphate of soda place themselves, which are distinguishable by their volume, their form of compressed tetrahedrons, their efflorescence, and the opaque glass which they afford in the fire. Rouelle recommends to add ammonia to the evaporated liquor, or whilst it is evaporating, or to saturate it while cold with this alkali and even to add an excess of it, in order that there may be no reason to fear the viscid consistence which the insulated phosphoric acid gives, and opposes the crystallization of the salt.

36. All that has been said of the evaporation of urine by the fire, belongs almost exclusively to the means and processes proper for extracting its salts. I shall now consider the operation under a new point of view, as adapted to lead to other results respecting the analysis of the urine. Citizen* Vauquelin and myself, in our enquiries respecting this liquor have found that when it was evaporated by a mild heat till it had acquired the consistence of a very thick syrup, the whole concreted by cooling into a crystalline lamellated or granulated mass, of a dark brown colour, and of a very pungent smell and taste: this mass did not resemble honey or caramel, as Rouelle has asserted. Excepting the proportion of carbonate of ammonia disengaged with the water during the progress of the evaporation; (for we convinced ourselves by performing this evaporation on the water-bath on close vessels, that
such

such a product was volatilized) this crystalline mass exhibit to us all the materials of the urine in a concentrated form; we therefore sought the means of analysing this extract of urine and separating its different constituent materials. We employed alcohol for this kind of analysis; it dissolved almost all the urinary matter with the aid of a mild heat; there remained undissolved only a small quantity of a grey, crystalline, granulated dirty powder, which cold water almost totally dissolved: the portion not dissolved by the water was phosphate of lime and uric acid; a lixivium of pot-ash separated the latter from the earthy salt. The water held in solution muriates of soda and of pot-ash, phosphates of ammonia and of soda. The whole of these saline matters that had escaped the action of the alcohol amounted only to some thousandths of the original weight of the urine; while the substance dissolved in the alcohol amounted to several hundredths of the liquor, and was much superior in quantity to all the saline matters taken together. This substance, already announced in the mother-water of the urine that had furnished the fusible salt, is therefore the most abundant and the most important material; it is this which gives it its principal characters, and will be particularly examined in one of the paragraphs of this article.

Here we have, therefore, a method of analysis which may serve to separate the different materials of the urine and even to determine their proportions.

proportions. It resembles that which is practised upon the mineral waters ; it requires only a well-conducted evaporation, a speedy refrigeration, and a successive treatment of the whole crystalline mass which it affords by alcohol, of the undissolved portion by water and by the ley of caustic alkali, as well as the graduated evaporation of the alcoholic and of the aqueous solutions. Indeed, the first of these solutions does not contain the colouring, odorous, and urinary matter simply, but always combined with muriate of ammonia, muriate of soda and benzoic acid in small quantity ; but we again find these last-mentioned bodies, and can even determine their proportions pretty accurately, by other means of analysis which I shall point out.

I have observed that by evaporating the urine in close vessels and by the heat of the water-bath, we might likewise obtain it of a thick and crystallizable consistence. I must add, that the first water which passes has but little smell ; that in proportion as the urine becomes coloured, thickened, condensed, and loses its water, it undergoes an alteration in its constituent matter which converts part of it into carbonate of ammonia, it is on this account that the last water obtained is charged with carbonate of ammonia and produces a lively effervescence with all the acids. The quantity of water which may be obtained from the distillation of urine in the water-bath ; carried so far as to reduce

ammoniacal and turns the syrup of violets green; that a portion of muriate of ammonia is sublimed, at the end of the operation, and that the coal contains, besides the muriate of soda, phosphate of soda, and lime, and sometimes a little iron.

39 Urine left to itself in a glass vessel at first loses its smell as it cools. That which is highly coloured and sparing, which is voided after violent exercise or when the atmosphere is very hot, becomes turbid throughout its whole extent, and deposits a grey coloured powder. The same phenomenon takes place in the critical urine voided at the termination of diseases; but we are not here to treat of these kinds of urine, but only of that of a healthy person, voided in the morning after sleep, and in the most ordinary circumstances. This liquid at first presents a light cloud which occupies the upper part of it; this cloud gradually augmenting in quantity subsides and becomes a sediment; different kinds of crystals are formed in 24 or 48 hours; there separates at its surface and upon the bottom of the vessel which contains it, small red crystals with brilliant facets: this sand of the urine is uric acid; the urine preserves its acidity as long as these crystals are deposited from it. In some days its colour becomes less intense, its acid nature disappears, it becomes ammoniacal and exhales that smell, and no more uric acid is then deposited, but there is formed at its surface a white, light,

light, and as it were glairy pellicle, in which some white prismatic crystals are perceived; the same salt attaches itself every where to the white or coloured cloud which swims under the pellicle; these crystals increase in number or in volume during six or eight days. These are six sided prisms terminated by pyramids with six faces; some are tetrahedral with pyramids of four faces. We have found them to be ammoniaco-magnesian phosphate. This salt does not exist in the fresh urine; it is deposited only at the period when the urine has become ammonical. Then, by filtrating the urine at the time when this salt no longer increases in quantity, we find it to be charged with carbonate of ammonia, turning the syrup of violets green, effervescing with the acids, and affording with the sulphuric and muriatic acids, after it has been evaporated to the consistence of a syrup, a very marked acetous odour, and containing little or none of the crystallizable and coloured matter, which has been indicated above, and is extracted from the pure urine by strong evaporation and refrigeration.

40. Thus the spontaneous alteration of the urine produces several important phenomena. The uric acid is first deposited in red crystals by mere cooling; the ammonia which is formed soon interrupts its separation; these are succeeded by a white cloud, formed of phosphate of lime and an albuminous substance, matters which are no longer soluble in the urine after the phosphoric

phoric acid, which at first was free, becomes saturated by the first portion of ammonia that is formed; the uric acid passes into the state of ammoniacal urate and forms part of the cloud; the proportion of the phosphate of ammonia and that of the ammonia both augmenting, and especially the latter, this unites with the phosphate of magnesia, and gives rise to the ammoniaco-magnesian phosphate, which crystallizes. The matter peculiar to the urine, which is converted so abundantly into ammonia, forms at the same time carbonic acid, which saturates the portion of ammonia exceeding the saturation of the uric and the phosphoric acids: and this is the reason why the liquor contains ammoniacal carbonate, effervesces with the acids, and even gives this salt crystallized by the action of a mild fire. At the same time acetic acid is developed, which the ammonia also saturates; so that we may obtain ammoniacal acetate by the distillation of the urine thus decomposed. The common source of these three new compounds, ammonia, carbonic acid and acetic acid, is in the particular matter of the urine, which has already been several times indicated, and which is eminently susceptible of fermentation; accordingly, the urine when once decomposed, contains only alkaline phosphate, and no longer presents this matter, or at least contains only a very small quantity of it; and it is for the same reason that it has formerly been so much recommended to let the

urine putrefy in order to extract its fusible or native salts. These are obtained both more abundantly and more pure when the urine is exposed to the strong heat of the sun: it keeps a long time without putrefying, becomes concentrated, coloured, and evaporates instead of experiencing the fermentation which quickly establishes itself in the shade.

41. All the urines however do not constantly and indiscriminately present this kind of effectual alteration which entirely changes their intimate nature. In the same individual whose urine presents this decomposition, it frequently happens that this liquid, instead of becoming covered with the saline pellicle, presents at its surface, on the fifth or sixth day after it has been evacuated, a coloured mouldiness after the deposition of the crystals of uric acid and the light white cloud. This mould, which is grey and green, increases during about twenty days; no white prismatic crystals are seen except below the pellicle covered by the mucus, and there they are few. The liquor, instead of being surcharged with carbonate of ammonia, has no ammoniacal smell; on the contrary an acetous emanation is disengaged from it by the muriatic acid; and when it is concentrated by evaporation, we again find in it the particular matter above indicated, and in still greater abundance. Citizen Hallé has well described this state of the urine, which is frequent, and which in the state of health, nearly equals in the number
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of days in which it is met with, that of the days in which the same liquid presents a strong ammoniacal decomposition. In his Memoir, Citizen Hallé, who has observed the phenomena above indicated (No. 40,) and from whom we differ only by the more precise appreciation of the matters separated and of the cause of their separation, since his object was only to describe the sensible phenomena of the spontaneous alteration of the urines, calls those *acescent* which comport themselves as has here been said, and has not neglected to mention the mouldiness which constantly accompanies them. We have found that these urines, which are less alterable and less decomposable, contain less albuminous substance than the preceding; whence we have concluded that the speedy alcalescence depends upon the presence of this albumen which is actually exhibited in them by means of tannin; for its solution precipitates the highly putrescible urines much more abundantly than those which are but slightly so. Thus we have two kinds of urine which each individual appears to void alternately or in different circumstances which have not yet been ascertained.

42. Urine unites with water in all proportions and is constantly miscible with it; the water diminishes its density and weakens its colour; it diminishes the viscosity of that which possesses this character: it dissolves or at least divides the glairy filaments which are some-

times found in it; it causes that which has an intense colour to pass into the lemon-yellow, and gives to the inflammatory and ardent urine the tinge of the urine of perfect health, as has long ago been remarked by Bellini. The acids have no action upon fresh urine; the oxalic only forms in it a precipitate of oxalate of lime, by decomposing the calcareous phosphate which it constantly contains: this is a means of determining the proportion of lime, and consequently of calcareous phosphate, which it holds in solution. All the acids produce effervescence with putrefied urine, on account of the carbonate of ammonia which it then contains in abundance. In urine, pretty strongly concentrated, the muriatic acid sometimes forms a precipitate of benzoic acid, and the nitric acid, a little concentrated, suddenly produces in it white crystals, of a pearly brilliancy, in great abundance, by uniting with the urinary matter which I have several times announced, and of which I shall soon treat in particular. When the urine is much putrefied, the nitric acid does not produce these crystals; the oxigenated muriatic acids discolours and whitens the urine. Most of the acids, especially the sulphuric, which when it is poured, concentrated upon the freshest urine, turns it brown, and it carbonates, gives a rose or red colour to all the ammonical products that are extracted from this liquid by distillation.

43. Almost all the earthy and alkaline matters exert a more or less decomposing action upon urine. It has long been known that when lime or alkalies are thrown upon it, a fetid ammoniacal odour is developed; which proceeds not only from the decomposition of the phosphate of ammonia, but also from the action of these bases upon the urinary animal matter. The solutions of barites, of strontian, and of lime poured into the urine, immediately form a precipitate in it; the two first separate the phosphate of lime from it, absorb the phosphoric acid which held it in solution, and precipitate the phosphate of barites or of strontian, which unites with the acid. This phosphate proceeds either from the union of the earths with the free phosphoric acid, or from the combination of the barites with the acid engaged in the soda, the ammonia and the magnesia: so that the barites decomposes all the phosphoric salts contained in the urine. The sulphate of barites is deposited when there is any sulphate of soda in the urine.

Lime, whilst it effects the same decompositions, precipitates only the phosphate of lime, either that which exists ready formed in the urine, or that which the addition of this earth determines with the free phosphoric acid, and the magnesia united with the acid, without touching the other salts. When the fixed alkalies are poured in excess into very recent urine, besides the
action

action already indicated, they prevent the uric acid from depositing itself, and retain it in solution. Ammonia does not produce the same effect. Amongst the salts, only the nitrates and the muriates of barites, of strontian, and of lime, produce precipitations by decomposing the phosphates. The muriates of soda and of ammonia, dissolved in cold urine to saturation, and afterwards exposed to spontaneous evaporation in the sun, crystallize with a very remarkable modification of their form. The first, instead of the cubic which it ought to have, assumes the octahedral form; and the second, from the octahedral form, passes into the cubic. We shall soon see the cause of this singular modification.

44. Some metals amongst those that are the most combustible, the most greedy of oxygen, are oxidized by the contact of urine, and are converted into phosphate by remaining in this liquid, with the aid of the free phosphoric acid which is contained in it. Citizen Vauquelin has observed, that the bars of iron with which the walls are supported in places appropriated for making water, constantly present this metal corroded, frequently in brittle scales, in grey or brown oxide, often swelled and filled with brilliant crystals. These brittle layers, when separated and lixiviated in water, give alkaline phosphates; and their undissolved portion, heated strongly in a crucible with charcoal, affords a well fused phosphuret of

N 2 iron,

iron, spherical, brittle, of a brilliant grey colour and granulated, which proves that this portion was phosphate of iron. It is necessary, therefore, when this metal is to be exposed to the contact of the urine, to cover it with a coating which may defend it against the action of the saline part of this animal liquid. There is reason to believe, though it has not yet been tried, that several other metals, especially zinc, tin, lead, and copper, are susceptible of being acted upon in the same manner by the urine.

Many metallic salts, particularly the nitrates of mercury, of lead, of silver, of zinc, &c. produce, when their solutions are poured into urine, a very abundant precipitate, consisting of phosphates and muriates. One of them, that of mercury, has been known more than a hundred years ago, by the name of *rose coloured precipitate*, and recommended by Lemery for medicinal use. Collected upon a filtre and dried, it presents phosphorescent scintillations when it is detached or rubbed in the dark. Heated in a close vessel, part rises in muriate of mercury; another part, when a strong heat is applied, gives phosphoric and luminous vapours. This is a very simple and commodious process for obtaining this combustible body; and it is far preferable to the very disagreeable evaporation of the urine, and to the treatment of its extract by distillation with charcoal.

45. Only four kinds of vegetable matters are employed with advantage for the analysis

of the urine: the oxalic acid, which precipitates the lime from it in an insoluble oxalate, and enables us to determine its quantity; the light blue colouring substances, namely, of turnsole, of mallows, which are reddened by this liquid, and which announce an acidity; tannin, which separates the albuminous or gelatinous matter in insoluble fawn-coloured flakes, and may serve for estimating the precipitation of this substance evacuated by the excremental liquid; and lastly, well rectified alcohol; this effects a kind of parting operation in the urine, by precipitating the uric acid, the phosphates, and most of the saline matters, which have less attraction for water than the alcohol has, whilst it retains in solution the more abundant urinary substance, with the muriate of ammonia, and portion of the muriate of soda. This last re-agent may especially be employed upon urine concentrated either by congelation or by evaporation, and we have seen above, that alcohol serves us for obtaining this urinary matter separated from all the other materials of the urine. No animal substance is employed for the analysis of the urine, and nothing is yet known relative to the action which the different animal liquids or solids are capable of exercising upon it; we have even been frequently embarrassed in medicine to decide upon the nature of some mixtures of different animal substances with the urine, mixtures which sometimes present themselves,
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and of which it is difficult to estimate the characters with accuracy. Thus it is frequently uncertain whether the urine contains blood, glairy matter, pus, milk, bile, which physicians frequently admit in it, without having adopted any certain means for determining with precision any of these mixtures. In this kind of research I know only one experiment inserted in the Philosophical Transactions of the year 1796, No. 21, in which Dr. Everard Home has ascertained that blood mixed while hot with urine coagulates into a mass, which, when steeped in urine, changed three times in 24 hours, imparts a red tinge to it during fifteen days, and afterwards is detached in white flakes, which deposited, are in sediments of the same colour; hence he has concluded that the blood, which does not become altered or putrefied in these circumstances, comports itself as when it is voided out of the bladder with the urine.

46. From all that has been said concerning the action of different bodies upon the urine, it results that the analysis of this liquid becomes singularly complicated by the means even that are employed for making it; that the multiplicity of principles which are contained in it, cause the nature of the materials which are extracted from it, to vary in a multitude of circumstances; that unless we constantly keep in mind the alterability of which the urine is susceptible, we may fall into great errors respecting the appreciation of these materials;

terials; that in particular the action of fire, which has so often been employed for its analysis, produces an alteration which changes the properties of most of its principles, even though it be applied in the most judicious and gradual manner possible: and that it would be still more important to find for this kind of analysis, than even for that of certain mineral waters, means capable of enabling us to ascertain its component principles, without changing its properties and composition. Such especially would be those re-agents, which at the very moment of their admixture with the urine, would each announce, without error or ambiguity, and by an effect equally sensible and constant, one of the principles which form a part of it. Unfortunately, those which have hitherto been discovered, indicate as yet only the smallest part of these principles: we are therefore obliged to combine several processes together, the results and the effects of which, when compared together, operate in such a manner as to leave no doubt respecting the matter which they announce. Thus the spontaneous evaporation, that by the fire, the fermentescible alteration, the action of alcohol upon the residuum of a gentle evaporation, and the phenomena produced by different re-agents combined in their results, afford at last an exact knowledge of the principles which constitute the urine, as I have shown, and conduct us, as I shall show to the particular

particular examination of its different materials, and to the better determination of what this urinary liquid really is.

SECTION V.

Of the Matters contained in the Human Urine, individually considered.

47. WHEN we seek a general result of all the analytical facts set forth in the preceding paragraph, and of all the phenomena which the chemical properties of the urine present, we find that the urine is not merely a saline ley, as has hitherto been asserted, but a solution of a great number of different matters, amongst which the saline substances occupy the least place. If we wish to form a faithful representation of all the kinds of analysis to which this liquid has been subjected, and of the notions which it has afforded to the authors, who have considered it under different points of view,—we shall soon feel the necessity of passing in review all the possible matters which chemists have hitherto indicated in the urine, of afterwards reducing the number of these matters to such as are constant, and may be considered as its true principles, since they are always met within it in their natural state;
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of considering, in the third place, such of these principles as are but seldom found in it, and are accidental to it; of passing from thence to the examination of those that are only hypothetical, and have been admitted in it without having been proved; and lastly, of examining the modified state and nature of the constant principles in the urine spontaneously altered.

48. I find, according to all the analyses hitherto collected, that chemists have admitted in the urine, either in the natural state, or in any state of alteration, whether they have well proved their existence, or have adopted them lightly, or even announced them hypothetically, thirty matters different from each other, besides the water which forms their vehicle, viz. 1, muriate of soda; 2, muriate of pot-ash; 3, muriate of ammonia; 4, sulphate of soda; 5, sulphate of lime; 6, phosphate of soda; 7, phosphate of ammonia; 8, phosphate of lime; 9, phosphate of magnesia; 10, triple phosphate of soda and of ammonia; 11, triple phosphate of magnesia and of ammonia; 12, free phosphoric acid; 13, uric acid; 14, benzoic acid; 15, acetous acid; 16, a particular acid different from all that are known; 17, urate of ammonia; 18, benzoate of ammonia; 19, acetite of ammonia; 20, carbonate of ammonia; 21, oxalate of lime; 22, a colouring matter; 23, an odorous principle; 24, albumen; 25, gelatin; 26, an extract; 27, saccharine matter; 28, an attenuated oil; 29, flex; 30, lastly

lastly, a body peculiar to this excremental liquid, which is the most abundant of all its principles. Each of these matters must be considered singly, in order to arrive at an exact notion of the nature of the urine, by examining whether it actually exists in it; how it has been discovered; in what state it is met with; the function which it performs; or the reason why it has been admitted without positive proof, &c.

49. The muriate of soda was the first saline matter known to exist in the urine: it was long believed that it formed its principal part, and gave most marked character. Stahl even went so far as to say, that the production of the phosphorous that is obtained from it was owing to this salt. It actually exists in it; it is extracted either by evaporating the urine by fire; whereby it is sometimes collected at the surface in small crystals, or at the bottom of this liquid by spontaneous evaporation, or amongst the mixed crystals of fusible salt, or of phosphates, obtained by the refrigeration of the urine evaporated to the consistence of a syrup. To it, is in part to be ascribed the precipitation of the urine by the nitrates of white metals. Chemists may have hitherto deceived themselves respecting its nature and its proportion, since when it is extracted by a slow evaporation, it assumes the form of octahedrons, instead of that of cubes, which it affects when it is pure.

50. The

50. The muriate of pot-ash, which has been announced by Rouelle, is pretty frequently contained in the urine, but it does not exist in it so constantly as the preceding; however it does not seem to be in some measure so necessary in its constitution as the preceding. In the confused crystallizations of the salts of the urine, we do not distinguish it from the other saline matters in the mass of which it is confounded; it is especially confounded with the muriate of soda which it accompanies, and the effects of which it imitates in the action of re-agents. There is reason to believe that its form is modified by the urinary matter like that of the muriate of soda, though we have no direct experiments upon this subject. This salt is obtained insulated and well distinguishable only by purifying with care, and at several successive times, the mixed saline masses, produced by the crystallization and refrigeration, and destroying by calcination the brown or black animal substance which soils them and impedes their separation. It is by a slow and patient labour upon the purification of these mixtures that we succeed in effecting it. It most frequently seems to form one of the accessory or accidental matters, and not one of the really constituent materials of the urinary liquid.

51. The muriate of ammonia has long been acknowledged in the urine by chemists; they have even formerly attributed its source

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or origin to this liquid, as also to the excrements of the animals. Rouelle the younger, however, was almost tempted to deny its existence, or at least he doubted of it. This arose from two circumstances, which, even whilst they announce the accuracy of the experiments of this able analyst, depended only upon his ignorance of the influence exerted upon this salt, by the urinary matter properly so called, which is the most abundant of all. This matter not only envelopes and prevents the separation of the muriate of ammonia which is always found to accompany it, and cannot be detached from it without difficulty, but it also adheres so strongly to it, that alcohol dissolves the muriate of ammonia at the same time with this matter. The greater part of this salt is therefore found only by long labour, and it can hardly be obtained separate till after the decomposition of the last urinary matter; thus it is disengaged and sublimed only at the end of the distillation of the extract of urine. A second circumstance which may have imposed upon Rouelle is that the muriate of ammonia cannot be obtained from the urine, as long as it contains the matter of which I here speak, except in the form of cubical crystals which must have been taken for muriate of soda.

52. The sulphate of soda has been announced in the human urine by Rouelle the younger. He even attached a certain value to this discovery, for in a particular inquiry respecting this liquid,

liquid, published in 1773, he took care to mention that he had already extracted this salt, and had exhibited it publicly, in 1770, in his course of Lectures at the Museum of Natural History. It must be remarked that other chemists have spoken of it before him, but have given no process for extracting it. Not having found this salt in a sufficiently clear manner in the urine, I have reason to think that Rouelle may have been deceived, either by the phosphate of soda, or, which is still more probably, by the ammoniaco-magnesian phosphate, the form and appearance of which sufficiently resemble those of the sulphate of soda, for its presence, very unexpected at the already distant period of this inquiry, to have been likely to escape him.

53. Several chemists, as well as the last-mentioned, have also announced the sulphate of lime in the urine. They have manifestly been led into an error by the calcareous phosphate, the presence of which in the animal matter was unknown in France till in the year 1775, especially in the urine. This is the more probable, as it was only after the white, earthy, insipid, insoluble deposition, which is formed in the course of the evaporation of the urine, and was separated from it, either by decantation, or by filtration in order to obtain the salts pure, that these chemists admitted its presence. Now it is at present known that these characters are found in the phosphate of lime, and that
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this is the salt which separates from the urine at the first formation of the ammonia.

54. The phosphate of soda is one of the most important and best known salts of the urine; being confounded for a considerable time with the phosphate of ammonia under the name of *microcosmic* or *fusible salt*, it was suspected by Pott and Magraff; was well separated from the above-mentioned salt by Haupt, Schloffer, Rouelle, &c. well analysed by the latter, and by Westrumb and Klaproth. It is very remarkable at first by its property of not affording phosphorus, and of remaining in the residuum of the distillation by which this combustible body is obtained; it was afterwards recognized as acting in the urine upon the metallic solutions, which were poured into it, constituting a great part of the precipitate which these solutions form in it, and becoming, in this form, susceptible of affording phosphorus with charcoal.

55. The phosphate of ammonia is one of the best known and best proved salts of the urine; it is that which beyond all the others has been the most examined, and has served with the most advantage to characterize this liquid, since it is from it that the phosphorus of urine was extracted. It is rarely obtained alone, though it tends to crystallize first after the inspissation, and by the refrigeration of the urine. It is always mixed with a certain quantity of phosphate of soda, and appears even to form
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with it a kind of triple salt, which constitutes the base of the native, fusible, or microcosmic salt. It is very distinguishable, when pure and insulated, by its property of affording ammonia by the action of fire, and of leaving phosphorous acid which may be obtained in the form of a transparent acid, soluble and deliquescent glass.

56. The phosphate of lime was discovered in urine by Scheele, in 1775; it had formerly been taken for a gypseous matter; it was afterwards spoken of as real sulphate of lime. Some good medical observers having seen it precipitated very abundantly from the urine in the affections of the bones, suspected it to be formed by the osseous matter; but being ignorant of the nature of this matter, they equally mistook that of the phosphate of lime in the urine. Scheele had moreover found that it was dissolved in it by means of an excess of phosphoric acid: and Citizen Vauquelin and myself, in our particular inquiries, have added to this discovery, that this earthy salt was precipitated spontaneously from the urine, when this liquid presented, in the first moments of its alteration, a production of ammonia, which seizing upon the excess of acid, rendered the phosphate of lime insoluble. The same effect is produced by the action of fire, and it is on this account that urine becomes so turbid during its evaporation. It is in part the cause of
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the precipitation of the urine produced by lime water, ammonia, the oxalic acid, &c.

57. The phosphate of magnesia had not been indicated in the urine previous to our inquiry; we were led to seek it by the discovery of this salt in some kinds of urinary calculi. Indeed we have found it insulated and pure only in very fresh urine; it is in part the cause of the precipitates formed in this liquor by lime-water, ammonia, the caustic fixed alkalies, barites, strontian. It is constantly found mixed with calcareous salts in the precipitates, and when we suffer them to macerate for some time in dilute sulphuric acid, the liquid portion being decanted and evaporated spontaneously, affords very pronounced crystals of sulphate of magnesia. It has not hitherto been possible to obtain it separate from the other salts of the urine, either because it mixes with several of them during their crystallization, or because the action of the fire forms ammonia, which unites with it and forms a triple salt. It is precipitated with most of the preceding, excepting the muriate of ammonia, when well rectified alcohol is poured into the fresh urine.

58. As to the triple phosphate of soda and of ammonia, announced as the tenth of the principles hitherto discovered or admitted in the urine, I have already said (No. 55) that this salt commonly exists in the aggregate or the mass of crystals which are obtained by the refrigeration and repose of the inspissated urine
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how this could be formed in the urine, and we have discovered that it is produced when the ammonia is itself formed in sufficient abundance to saturate all the free phosphoric acid of this liquid, and the excess of phosphate of ammonia thus decomposed seizes upon the sulphate of magnesia. In this case, the ammoniaco-magnesian phosphate becoming, like the triple salts of the same nature, less soluble than each of its two component salts were separately, separates from the urinary liquid and tends to crystallize, as is frequently seen in the spathose white layers of some calculi. Such is the origin of the elongated prismatic white crystals, which are seen to deposit themselves in urine that has been kept for some days, both upon the sides of the vessels which contain it, and under the crust which then covers the liquid.

60. The free phosphoric acid of urine was really discovered by Scheele, when he observed that the phosphate of lime was dissolved only by means of this acid. Citizen Berthollet paid much more attention to the presence of this acid than Scheele had done, who had indicated it, if I may use the expression only transiently. Several physicians had long before perceived the natural acidity of the urine. Col. de Villars had especially announced it in his course of surgery; and nevertheless it was a generally received opinion that the urine was of an alkaline nature. The embarras
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taffment in which the chemists found themselves in this respect, proves that they did not distinguish the tendency to alkalescence by which this liquid is characterized, from its truly and constantly acidulous nature at the moment when it is evacuated out of the human body. It is to the phosphoric acid, as the strongest and most powerful of those that are found dissolved in the urine, that this acidity is to be ascribed ; but we must not suppose it to be pure and insulated, since it is engaged in a real combination with the phosphate of lime which it renders soluble. It must be conceived, on the contrary, that were this acid pure and without calcareous phosphate, the urine would be much more acid. We have already seen that this portion of acidity is destroyed by the first formation of ammonia, and that it is then that the phosphate of lime, ceasing to be soluble after this saturation, is deposited, and renders the urine turbid in proportion as it abandons it; the urine, therefore, is an evacuant of phosphoric acid in excess.

61. The uric acid is one of the most singular and useful discoveries of Scheele. After having found it in the calculus, or stone of the bladder, he discovered it in all kinds of human urine; he observed it to be precipitated by the cooling of this liquid, and to form what is known by the name of sand; it is this which produces those crystals of a reddish or light ruby colour, which deposit themselves upon

the sides of the vessels in which the urine is received. It is to it that Scheele attributes the grey or peach-blossom coloured precipitation of the critical urine at the termination of diseases. It undoubtedly contributes to the acidity of this liquid, though its own be but extremely weak. Being one of the least soluble principles of this kind of animal lixivium, it is separated first from its natural solvent, in which it is more soluble when hot than when cold, and which it abandons by the mere diminution of its temperature. As a particular animal production, we shall see, in the following article, that it possesses very distinctive characters, and forms one of the most frequent materials of the urinary concretions.

62. Scheele is likewise the author of the discovery of the benzoic acid in urine ; for Rouelle the younger who had found in it that of the cow and of the camel, had not sufficiently distinguished it to ascertain its nature, as the Swedish chemist does. We have met with it in all urines, and Scheele had especially admitted in that of infants. It sometimes sublimed from the extract of this liquid when acted upon by a strong fire, it may also be precipitated from it after its evaporation and concentration. There is reason to believe that it proceeds from the aliments, especially in the mammalia where it exists most abundantly. Its presence in the urine of infants, who subsist only upon the milk of their nurses, however renders this opinion less ad-

ible, and affords ground to suppose that formed in the bodies of the animals. It is little abundant and so much diluted in the case of adults, that it is not easy to reckon it amongst the causes of its acidity ; it is scarcely more than an accessory matter, indifferent to the quality of this liquid, and yet found constantly enough to prove that its excretion by this emunctory enters into the plan of excretion.

The acetous acid does not naturally exist in urine. Though discovered, nearly fifty years ago, by Pott amongst the distilled products of urine, is liquid. Chemists have not spoken of it.

Citizen Vauquelin and myself, in our series of experiments upon the urine, have ascertained that it is constantly formed by the fermentation which takes place in it ; that the constituent materials constantly exist in it ; that it is the product of its first alteration ; that it accompanies the production of ammonia. We must not conclude from hence, as Van Helmont, that urine is susceptible of undergoing the vinous fermentation, or of being changed into ardent spirit ; which was denied with justice by Boerhaave, though, as we shall hereafter see, there are some cases in which this property may be found in it. It is now sufficiently known that the previous formation and existence of alcohol are not always immediately necessary to the production of the acetous acid, that it is formed in many circumstances which

which have nothing to do with the alcoholic fermentation.

64. Professor Scherer, of Jena, in a letter to Citizen Van Mons, written in the middle of the year 1797, speaks of the experiments of Dr. Gaertner, of Calw, in Swabia, upon the urine, and of an acid peculiar to this liquor. This physician thought he had found, after a rigorous examination of this evacuation, that the acid of the urine, which he had taken at first for phosphoric acid, had other properties which it differed from it, as well as from all other known acids. According to him, the acid is volatile, and sublimes by a strong heat; the sulphuric, nitric, and muriatic acids, precipitate it from its saline combinations, partly in the form of gas, partly in that of a fixed acid which by evaporation affords scales unalterable by the air and odorous. Though these experiments are a little extended and multiplied, they however lead me to conclude that Dr. Gaertner has confounded, in his researches, the benzoic acid with several of the phenomena produced by the particular urinary matter, with which I shall soon occupy myself, and that it is in these two substances that he has imagined he had found a new acid different from all that are known. I therefore consider his new acid as an imaginary substance, and his experiments as in no respect invalidating the presence of the three acids, the phosphoric, the uric, and the benzoic, in urine.

or in part free in well constituted urine, when fresh and recently voided.

65. The urate of ammonia had not been indicated in the urine previous to our last researches. After having discovered it in some calculi of the human bladder, we convinced ourselves that it existed in putrefied urine. When ammonia is produced in it in sufficient abundance to saturate all the phosphoric acid and precipitated the earthy salts, the excess of this alkali seizes the uric acid, saturates it and forms that salt which deposits itself, because little soluble, above the phosphate, and has a light fawn colour. This salt is well characterized and very distinguishable by its solubility in the leys of the caustic fixed alkalies, and by the very abundant disengagement of ammonia which accompanies its solution in those reagents. The urate of ammonia exists therefore only in altered urine, and is not natural in this liquid.

66. The benzoate of ammonia is in the same predicament with the foregoing; it is not contained in recent urine; it is only found in this liquid after it has undergone that fermentation which changes its nature: it is formed only at the expense of the ammonia, one of the constant and most abundant products of this fermentation by which its nature is changed; and when its quantity is sufficiently considerable to saturate at once the phosphoric acid, the uric acid, and the benzoic acid of the urine. Thus, in the
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advanced putrefaction of this liquid, the benzoic acid is no more free in it, but entirely saturated with ammonia, and at this period it would be in vain to seek it in its pure state. In order to obtain it in this state, it would then be requisite to separate it from this alkali. It is in this manner that strongly evaporated urine, in which the heat has promoted, at the same time with the putrefaction, the formation of the ammonia, gives, by the addition of the muriatic acid a precipitate, always sensible and sometimes very abundant, of benzoic acid in small scales. The nitric acid must not be employed for this purpose; for this would cause to be precipitated with the benzoic acid, another crystalline matter infinitely more abundant, which would entirely disguise it. It is this undoubtedly which deceived Dr. Gaertner, when he thought he had separated a particular acid from the urine: he may indeed have obtained a body different from all others; but this was not an acid, as I shall soon show more in detail.

67. The acetite of ammonia exists, according to our experiments, in fermented urine. As this particular fermentation consists in the simultaneous formation of ammonia and of acetous acid, and as the first of these productions is infinitely more abundant than the second, it is evident that the acetous acid cannot exist free and insulated in the urine, but combined with ammonia. It is undoubtedly on account of this saturation, which takes place

as speedily as the formation of the urinary acetous acid, that this acid has so long escaped the chemists, who, in fact, were almost entirely ignorant of it before us. It is on this account that when altered urine is distilled, water is obtained from it which contains ammoniacal acetite, or *Spiritus Mindereri*. It is also on the same account that when we wish to obtain pure acetous acid from the fermented urine, it is necessary to distil it with the addition of sulphuric or muriatic acid. It is unnecessary to remark that this saline combination, so far from being one of the constituent elements of the urine, is, on the contrary, that product which indicates the most profound alteration of that liquid.

68. The carbonate of ammonia has long been known as one of the matters that are extracted, the most easily and the most abundantly from urine. Haller was even astonished that this liquid was not preferred to many other animal substances for the preparation of this salt, which has been known for nearly two centuries by the name of volatile salt of urine. It is not however one of the true materials of this liquid; it exists in it only when the urine has undergone a great and effectual alteration; when, in the last periods of its decomposition, the very abundant ammonia has saturated the phosphoric, uric, benzoic, and acetous acids; when the latter acid, being formed as abundantly as possible, leaves the carbon and the oxygen sufficiently insulated

insulated from the other constituent elements of the urine, and sufficiently approached to each other to unite by their binary attraction, whilst the ammonia, always continuing to be produced, saturates and fixes this acid, becomes fixed itself, as fast as it is produced. Thus the carbonate of ammonia is the last term, and as it were the last testimony of the decomposition of the urinary animal compounds. At the end of the putrefaction of the urine it is so abundant in it that it strongly turns the syrup of violets green; that it produces a brisk effervescence with the acids; and that by the mildest fire, even on the water-bath, it affords by a well conducted distillation, both water charged with carbonate of ammonia, and carbonate of ammonia in sublimed crystals: accordingly it is employed with advantage in several works for procuring this salt.

69. Though Citizen Vauquelin and myself first found and indicated the presence of the oxalate of lime in the kinds of urinary calculi known by the name of mural or muriform; we have not yet been able to find this salt, either insoluble or soluble only by the aid of some acids in the human urine. It does not appear to form one of its constituent materials in its natural state; but to be contained in it only in some particular morbid circumstances. In fact, it is easily conceived that if, by any cause, oxalic acid is formed, either immediately in the urine, or in other situations, and if, in the latter

after case, it be transported into the kidneys; this acid must immediately decompose the phosphate of lime, which naturally exists in it, and form a calcareous oxalate, which is hardly soluble in the excess of phosphoric acid. Accordingly it is not allowable to conceive the existence of the oxalate of lime unless we at the same time, suppose the absence of the phosphate of the same base, or at least we must admit the first unless in so small quantity, supposing it to be found along with the second, that it can then be scarcely appreciable. One of my pupils, however, assures me, that he has lately found this salt abundantly precipitated in the urine of an infant afflicted with an heli-intic disease, under which he perished. I shall speak of it again in one of the subsequent numbers.

70. Some chemists have admitted a particular colouring matter in the urine, induced by the ways particular, and sometimes very remarkable colouration of this liquor. No one, however, has accurately proved its existence. It has been pretended, in several medical theories, that this colouring part was bile, and Boerhaave had successfully combatted this opinion at the commencement of the present century. Rouelle the younger, first placed this matter in its true light, by showing that the colour of the urine was owing to an extractive substance, reflecting the nature of which it was difficult for him then to conceive an exact notion, but with some

some of the most singular properties of which he was evidently acquainted. We shall find hereafter that, without admitting a particular colouring principle in the urine, it is to this matter which especially characterizes this liquid which forms its most abundant constituent part and which gives it the most of its distinctive properties, that its colour is to be ascribed and this matter is, as we shall see, one of those which Rouelle called extractive. Its proportion which is very variable with respect to that of the water which holds it in solution establishes the principal differences which exist in the different urines, since, according to the ingenious remark of Bellini, we may, with a highly coloured and concentrated urine, and water added in different proportions, imitate all the varieties of colour which this liquid is capable of presenting, according to a multitude of circumstances.

71. The same is to be said concerning the odorous principle of the urine. However peculiar to this humour, however distinct and characterized it may be as an individual odour belonging to no other known matter, resembling a kind of aromatic and even strongly aromatic exhalation, it is unnecessary in order to explain it, to admit a particular odorous principle in the urine. Its source is found in the substance which gives it its colour, and which truly constitutes the urine by all its properties. This odour is so fugitive, so little durable, that

it can scarcely be seized except at the very moment when the very pure, and very healthy urine is voided from the bladder; it is very perceptible in hot urine, but is weakened and disappears almost entirely in this liquid when it has cooled; and it becomes quickly altered from the first period of the decomposition which so soon takes place in the urine, and it is susceptible of a great variety of modifications from many accidental circumstances. It becomes fetid by the use of asparagus or cantharides; it is rendered acrid by the marine aliments, fish, the testacca; pleasant and analogous to that of violets by turpentine, the resins, the balsams, and several gum-resins. It unites with that of garlic, of the vegetable acids, of camphor, of sulphur, &c. &c.

72. No chemist has yet ascertained with precision the presence of the albuminous matter in the urine. It is to Citizen Seguin that we owe the first notion of it, in his researches upon tanning; he first remarked that a solution of tan poured into the urine, produced in it a very varied precipitate, according to the different states of the subject; he has even suspected that this test by tannin, might be of utility in medicine, for announcing the proportion of nutritious substance that passed off by this excretion. But he has not explained himself accurately, respecting the nature of this substance, and it is by our successive experiments that if not positively ascertained, at least, we have begun

gun to prove that the albuminous matter may sometimes be evacuated by the urine as a part of this liquid. We have not, however, obtained it separate, we have not been able to insulate it sufficiently and obtain a sufficient quantity of it, to determine its nature with certainty: it does not appear, supposing it to exist in it in some preter-natural cases, that it constantly forms part of the urinary liquid or that it can be reckoned amongst the number of its true principles.

73. It is rather to the gelatinous substance than to a true gelatin, that the observation of Citizen Seguin of which I have just spoken applies; for it is known that his experiment upon the precipitation of the animal matter by tannin, and upon this unalterable and imputrescible tanned combination, are especially relative to the gelatinous substance, as he has particularly insisted upon this very mark properly in the solution of glue. In announcing therefore the effect of tannin upon urine, and the indication of its state by this effect, it will accord better with the consequence of his discoveries to attribute its cause to a gelatinous matter. Besides, the existence of the gelatin in the urine corresponds better with the frequently viscid and mucous state which the liquid presents in a multitude of circumstances as well as with the glairy flakes or filaments which so frequently swim in it, or are precipitated from it, especially in certain affections of the bladder.

bladder. It is even scarcely to be doubted that this gelatin exists in the urine here mentioned; but the question is to know whether this matter be constantly contained in it? whether it form one of its ordinary materials? whether it exists in the natural state? in a word, whether urine of the ordinary limpidity or more limpid than ordinary contain amongst its principles the gelatinous substance? It has sometimes been observed that urine, after having been evaporated, and after having furnished the greater part of its salts, assumed a viscous form; it has even been observed to become fixed in a mass; but this property depends much more upon the matter which is peculiar to it, and of which we shall soon treat. It is not therefore by this property that the existence of the gelatin can be ascertained, and we must only have regard to the precipitate formed by the tannin. Under this relation, most urines afford only a slight precipitation, and that not sufficiently sensible to authorize us to consider the presence of the gelatine as demonstrated, at least not as constant.

74. An extract peculiar to the urine was admitted by Rouelle, the younger, who considered it as the cause of its colour. He carefully distinguished it from the saponaceous matter, as well from another extract which he designated by the name of saponaceous. He described it as a coloured, brown matter, sufficiently acrid and sapid, soluble in water, but not in alcohol, susceptible

susceptible of assuming and preserving the dry form, and easily separated by that means from the saponaceous matter. Though I cannot deny the existence of this extractive body in the urine, I shall however remark, that it is not obtained either so easily or so abundantly as Rouelle has asserted; that it is not an extract to be compared with that which is so called in the vegetables. This principle, admitted by the French chemist, must not be confounded with the entire product of the evaporated urine, which is designated by the name of extract of urine, and is a mixture of a great number of different matters, especially of saline substances, enveloped and every where covered with the matter peculiar to this liquid. Rouelle carefully distinguished the extract of which I here speak from all the other materials of the urine, and did not understand by this name the entire product of the evaporated urine. For the rest, since his experiments no chemist has spoken again of this principle, which must be ranked amongst these which I call hypothetical.

75. Sometimes a saccharine matter has been found in the urine, especially in a kind of diabetes or urinary flux, which on that account is called the *diabetes mellitus*, or the saccharine diabetes. In England especially the extraction of a sort of saccharine body from the urine of diabetic patients, has been the object of the labours of several physicians. I shall speak more in detail concerning it in one of the subsequent

graphs; it is evident that the object in question is not a common or ordinary principle of the urine, since it is not in the natural state at which saccharine matter is found, which is only the product of a morbid alteration. This body must therefore be ranked amongst fortuitous or accidental materials of the urine, not amongst those which constitute or characterize it. This is so true, that when it is in it, the liquid voided from the bladder is no longer what it ought to be in the state of health; it is no longer real urine which is discharged; it is neither the same fluid which is excreted, nor the same excrement that is voided, nor the same function that is performed. It is even the general notion which we ought to form of the renal evacuation so changed or modified by diseases, as no longer to possess the character which properly belongs to it, and no longer to resemble urine properly so called, in a word, not to be urine.

5. Several chemists have thought to explain the particular nature of the urine by admitting an attenuated oil, the ultimate products of the efforts of life, and of the motion of the vessels. Boerhaave has insisted the most upon this idea, which we find very fully and copiously developed in Haller's grand physiological work. But it is evident that it was for want of accurate facts and positive experiments upon the nature of the urine, that the medical chemists adopted this opinion, and that this pre-

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tended oil was only a hypothetical principle, such as were very easily adopted at the period when this was admitted. Moreover when we enquire to what matter contained in the urine, this acrid oily principle, the ultimate product of the vital action, approaches the nearest, we find that the notion which chemists had conceived of it, at the commencement of the present century, corresponds, if not accurately, at least by sufficiently marked relations, with the most abundant, urinary substance, which truly constitutes this kind of excremental liquid, and which I reserve for a particular consideration, on account of its importance, in the paragraph immediately following. We must not therefore admit oil properly so called, or the attenuated oily principle in the urine; but consider it only as an improper synonym, as a bad and false denomination, given to one of the most important and most remarkable principles of this liquid.

77. No chemist has yet discovered or indicated silica in the urine; but as this earth has presented itself to us in the analysis of a calculus of the bladder, and as it must have proceeded from the urine in which the calculus had deposited itself, we have concluded that this liquid might in some cases contain the siliceous earth. Indeed, amongst several hundreds of calculi of the bladder, which of themselves are productions that fortunately are pretty-rare in the urine, we found only one in which this earth formed a part of the nucleus. This
proves

proves that the presence of this earth in the human urine is an extremely rare circumstance; accordingly, I shall not yet rank it amongst the materials of this liquid. It is only by accident, in consequence of morbid circumstances but little frequent, as it appears, that silex forms part of this excrementitious humour. However, when we reflect that this earth is now found much more frequently in waters and in the vegetable matters than was believed to be possible, it is evidently natural to believe that it may exist in the aliments, and likewise that it may be evacuated with the urine. Possibly future researches, more accurate than those that have hitherto been made on this subject, may teach us, that this earth is to be met with more frequently than can yet be suspected, in the urinary excretion.

78. Lastly, the thirtieth and last principle that has been found in the urine, is that which is met with in it in the greatest abundance, the presence of which I have already repeatedly indicated, which has been mistaken by confounding it sometimes with an attenuated oil, sometimes with colouring matter, and sometimes with a kind of saponaceous extract: it is this substance which truly characterizes the urine, and is alone much more considerable than all the other materials of this liquid taken collectively, without which its urine would not be what it is; the more abundant quantity of which gives to this liquid its very marked

urinary characters, and the variable proportion of which produces the most striking differences in the several urines. As this matter performs a very important part not only with respect to the urine, but also with respect to the whole mass of the body, and as its distinction, its characters, and its properties, have hitherto almost entirely escaped the observation of chemists, I shall describe it particularly and carefully under the name of urée.

79. According to what I have indicated concerning each of the different materials which have been found or admitted in the urine, we may distribute them into four classes; the first comprehending those which are constantly found in this liquid; the second, those which are found in it only rarely, accidentally, and frequently in consequence of modifying causes; to the third I shall refer the matters formed by fermentation, and which are extracted only from the altered urine; and in the fourth, I shall place those which are only conjectural and hypothetical.

Eleven of the thirty principles indicated are constantly exhibited in the analysis of the urine, and truly constituent, so that they may be considered as excrements which must be discharged out of the human body by this way. Such are the urée, the gelatinous animal matter, the muriate of soda and of ammonia, the phosphates or soda and of ammonia, separate or united in triple salt, the phosphate of lime, the phosphate

phosphate of magnesia, the phosphoric acid, the lactic acid, and the benzoic acid. Their respective proportions vary according to a multitude of circumstances ; but natural and well constituted urine is always a solution of these eleven substances in a large quantity of water.

80. Many chemists have spoken of several other matters in the urine, and their assertions are too deserving of confidence, for us not to admit these matters, though the latest experiments show that they are rare and accidental in it. In this second class of materials of the urine we must place the muriate of pot-ash, indicated by Rouelle the younger ; the sulphate of soda, admitted by the same chemist, as well as the sulphate of lime ; the calcareous oxalate which must form part of it in the case of the production of a mural calculus ; the saccharine substance, which exists in the diabetes mellitus, and perhaps in some other morbid circumstances, flux and the albumen. We see that these matters may exist at the same time with the twelve preceding, that they are not contradictory to their presence, and that their attractions permit them to meet and remain in it with preservation of their nature, and without changing that of the constant and as it were essential materials of this liquid.

81. When the urine is fermented, besides the matters which it constantly emits, there are formed in it, at the expence of the urée, and the animal substance, the only alterable
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and fermentable principles which it contains, acetous acid, ammonia, and carbonic acid; so that we then find in it, besides these principles, the following additional ones, the benzoate, the urate, and the acetite of ammonia, ammoniaco-magnesian phosphate, and carbonate of ammonia. The urée is no longer either so abundant or in its natural state; its brown colour, and the dark coloured depositious which appear in it, prove that a portion of carbon is separated: accordingly, when once fermented or altered by the spontaneous movement which is so early and so soon excited in it, the urine is no longer really the same liquid that it was in its natural and healthy state.

82. As to the principles which I consider as hypothetical, because their existence has never been proved, and because their presence has been admitted only according to mere suppositions, I find only five matters which are truly in this predicament; namely, the particular acid of Mr. Gaertner, the colouring matter, the odorous principle, the extract, and attenuated oil. I have proved in the preceding numbers, that these principles are in fact rather imagined than demonstrated in the urine. It must be evident, that by this detailed consideration upon each of the materials, I have ascertained with precision the true constituent matters of the urine, and given a more exact notion concerning this liquid than had hitherto been presented. It is also easy to perceive that I have had reason
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son to present the urine, both as the animal liquid that has given occasion to the greatest number of discoveries, and as one of the matters which have furnished the most useful applications to the physics of animals.

SECTION VI.

Particular Examination of the Urinary Substance, or of the Urée.

83. I have already indicated a great number of times, in the preceding numbers of this article, the particular matter of which I am about to treat. It is this which gives the urine its colour, its smell, part of its taste, and in general all the properties which characterize it as the urinary liquid. Without its presence there would be no real urine; and when the liquid discharged from the bladder does not contain it in certain circumstances, it has no longer the true characters of urine, but is in some respect a liquid foreign to its proper nature. The chemist, the physiologists and the physicians have never yet examined this matter under a similar point of view; and yet it is worthy of all their attention, both with respect to the singular properties which distinguish it, and to the important relations which it presents with the phenomena of the animal economy.

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Boerhaave, Margraff, Schloffer, and Pott, had, however, a notion of its existence. Rouelle, the younger, had described some of its properties, especially its crystallization, its deliquescence, its solubility in alcohol, its abundant conversion into ammonia, and he attempted to distinguish it by the name of saponaceous matter, Scheele badly designated it by the name of extractive matter. Cruikshanks, of late years, has better understood some of its particular properties, especially its crystallization with the nitric acid, but he still calls it extractive animal matter.

84. In our long and laborious researches upon the urine, Citezen Vauquelin, and myself, have paid a particular attention to this substance; because we had found it to be the cause and the source of several very remarkable properties; it presented itself to us in a multitude of circumstances and phenomena, which had not been sufficiently observed by the chemists; it has exhibited to us its peculiar nature, very different from that of any other urinary substance, as constituting and characterizing the urine, so that this liquid seemed to us not to be capable of existing without it.

In our profound study of it, we found the necessity of giving it a name which might destroy the ancient, imperfect, and even erroneous notions which had been given concerning it before us, and which might serve to characterize it as a very distinct animal matter, forming the urine by its solution in water. On this account

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re have adopted the word *urée* which is sufficiently similar to that of urine, from which it differs only by its termination, in order always to call to mind its particular nature, and its intimate relation with the production of this liquid. Thus it will no longer be possible to confound it with an extract, a soap, or an oil, the properties of which differ in many respects from those of this particular matter.

85. It is necessary we should first relate the manner of obtaining the *urée* as pure as possible, for we have not yet been able to insulate it entirely from some of the other materials contained in the urine. I have already said that the urine, evaporated by a mild heat to the consistence of thick syrup, concreted, by cooling, into a solid, brown, granulated mass, which Boerhaave and Rouelle had compared to a sap or kind of honey. This mass is a mixture of twelve different matters, since it is really an entire extract of the urine; but the *urée* forms the greater part of it, and its solubility in alcohol, whilst most of the other materials of this liquid are not soluble in it, has assisted us to obtain it almost pure. For this purpose we pour upon the brown granulated mass four times its weight of well rectified alcohol, at several times, in a vessel placed upon a mild fire; the liquor, whilst it dissolves almost the whole of it, assumes a dark brown colour, and leaves the greater part of the saline matters considerably pure: Rouelle had recommended a similar means

means for purifying the salts of the urine. The alcoholic solution, placed in a retort of glass, must be distilled on the sand-bath; there passes over a fetid alcohol, charged with carbonate of ammonia, and effervescing with the acids, which give it a rose colour. When the liquor is of the consistence of a thick syrup, it hardly contains any more alcohol; as it cools it crystallizes into laminæ crossing each other, seemingly quadrangular, cut off or imperfect at their sides, of a brilliant yellowish white colour, and brown in some of their surfaces. This is the urée mixed with a small quantity of muriate of ammonia, as well as with benzoic acid, of which it is impossible entirely to deprive it; but it is sufficiently pure to present the properties which characterize it.

86. The whole of the urée prepared in this manner is crystallized; but it has hitherto been impossible for us to determine, with exactness, the form of its micaceous brilliant laminæ, always grouped together, and pressed against each other, and always incomplete. Though hitherto incapable of an exact description, this form, however, presents an appearance which sufficiently distinguishes it from any other animal substance, of whatever nature it may be, for it to be impossible to confound it, or not to distinguish it with ease. It exhales a strong, fetid, and alliaceous smell, which is repulsive to animals, and seems to affect the nerves and the brain in a dangerous man-

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ner when exposed to it for some time. It adheres to the vessel which contains it; it is rather difficult to cut or break it; it is hard, granulated, very consistent at its centre; it becomes soft and like thick honey at its surface; it strongly absorbs the moisture of the atmosphere, and the portion dissolved by this deliquescence runs in a thick liquid round the whole mass, which it detaches in part from the sides of the vessel, and which it turns brown in all the points at which it insinuates itself. Its acid, pungent, and very disagreeable taste, resembles that of the ammoniacal salts.

87. The urée introduced with caution into a retort, with a wide and short beak, to which a receiver and the pneumato-chemical apparatus is adapted, comports itself by the fire, and in distillation, in a manner peculiar to itself. It is quickly fused; at first there is raised a white fume, which condenses upon the sides of the retort in laminæ, which are easily distinguished to be benzoic acid. Soon the first sublimate is succeeded by crystallized carbonate, the production of which continues, without interruption, to the end of the operation. Neither aqueous liquor, nor oil is obtained, but the sublimed product is turned brown. The air of the apparatus impelled into inverted glasses, placed at the extremity, is impregnated with a fetid alliaceous odour, resembling that of putrefied fish. It carries off in solution carbonate of ammonia, which is discovered by the precipitate which

which it occasions in the well-water which is frequently employed for filling the pneumatoc-chemical vessel. Its infectious odour becomes horrible, and insupportable, when the heat is very intense. The matter in the retort is then dry, blackish, and covered with a raised white crust, which elevates itself at last in a heavy vapour, and attaches itself to the lowest part of the vault, and of the retort; this is ammoniacal muriate. We observe nothing more in this operation, carried on for two hours, and till the retort is perfectly red-hot, and ready to melt. The coaly residue, when water is poured upon it, exhales a smell of Prussic acid; burned by an open fire, it exhales also ammonia, and a Prussic smell of bitter almonds; it leaves one hundredth of the weight of the primitive matter of an acrid white cinder, which turns the syrup of violets green, and contains a small quantity of carbonate of soda.

88. Though several times repeated, and with all possible attention, however disagreeable it might be, this distillation could afford us only some general notions respecting the nature of the urée; it exhibited to us in it benzoic acid, muriate of ammonia, and a small quantity of muriate of soda accompanying this matter; it ascertained to us that it was itself very decomposable by the fire, affording ammonia as the most abundant of its products, but neither water nor oil, forming also, carbonic acid, and Prussic acid, affording neither hydrogen gas, nor car-

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bonic acid gas, nor azotic gas, at least not in sufficient quantity to be obtained insulated. We were obliged to conclude from this kind of analysis, that the constituent principles of the urée, when separated by the fire, unite, almost all, two and two together, the carbon with the oxygen, the azote with the hydrogen; that they united all together only in a smaller portion, in the proportions proper for forming a small quantity of Prussic acid; that the large quantity of ammonia, which greatly exceeds the other products of this decomposition, announced that the proportion of azote was greater than that of all the other principles of this matter; and lastly, that the formation of carbonic acid, in sufficient abundance to saturate the ammonia, proved the presence of oxygen in it, so that the urine appeared to be a quaternary compound of azote, hydrogen, carbon, and oxygen, in which the first of these principles predominated.

89. The urée is extremely soluble in water, as is proved by its deliquescence. When we pour a little water upon it, it absorbs it pretty quickly, and is soon diluted with it, producing a sensible refrigeration, and assuming a brown colour and a thick state. When we throw crystalline masses of urée into this liquid, it melts in it, presenting thick brown streaks. When the solution is sufficiently liquid and clear, which is effected with four or five parts of water to one of urée, it exhales, when agitated in the air, some white fumes, which
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appear to depend upon the disengagement of ammonia, that becomes sensible by the odour developed at the same time. This liquor, when left to itself in a well-closed vessel, keeps for a long time without alteration; when an animal matter is added to it, whether albumen or gelatin, it ferments at the end of some days, and is converted into acetous acid and ammonia. It is to its great proportion and its purity that the inalterability of some of the highly coloured urines is to be ascribed; whereas those which contain at the same time a gelatinous substance, which performs the function of a ferment, become altered more or less easily and quickly.

90. The aqueous solution of urée, treated by fire, presented to us a phenomenon much more important and instructive than the distillation of the dry urée alone. Distilled by a mild fire, carried to ebullition, it afforded very clear water charged with ammonia; when the liquor was inspissated to the consistence of a syrup, four parts of water were added to it, and the same product was obtained, slightly coloured; three other successive additions of water furnished also liquid carbonate of ammonia, only more and more coloured, and from which a small quantity of carbon was precipitated. We thus obtained nearly two-thirds of the weight of the urée in carbonate of ammonia, and the portion which remained in the last residuum was still urée not decomposed and susceptible of being converted into this salt. Thus the mere

temperature of ebullition, which does not sensibly alter the animal substances (properly so called) in their intimate composition, easily decomposes the urée which presents an equilibrium much less permanent in its nature, and a conversion into carbonate of ammonia, infinitely more easy, because it is more abundant and more prompt than in any other animal substance, whatever it may be. So that there is this very remarkable difference between the ordinary animal compound, and this essentially urinary compound, that the first undergo coction, and become more fit for digestion by this boiling temperature of the water, whilst the urée is decomposed and converted into ammonia and carbonic acid by this degree of heat. This easy and very remarkable decomposition is more especially peculiar to this product of animalization with relation to the formation of the carbonic acid, which, in the other matters in which it is observed, generally requires a temperature much superior to that of boiling water. Every thing, therefore, concurs to prove, that the urée is more decomposable, and much less durable or permanent in its composition, than any other animal matter hitherto known; and that it requires only a slight change of equilibrium to cause it to pass into the state of ammonia, and of carbonic, Prussic, and acetous acids.

91. Amongst the alterations which the acids produce upon the urée we must especially dis-

tinguish that which the nitric acid presents, since the action of the others has nothing comparable to it, or that particularly merits our attention. Indeed, the concentrated sulphuric acid burns it; but the muriatic, the phosphoric, the fluoric, and the carbonic, produce no alteration upon it. The oxygenated muriatic acid decomposes it, separates it in part from the water in which it is dissolved in the form of yellow flakes, precipitates carbon from it, discharges from it carbonic acid and azotic gas; it also reduces a small portion of it to the oily state, and decomposes the ammonia which it forms at first, which is perceived by the long effervescence and the very small but continual bubbles which are disengaged from the liquor during a very long time. The product of this effervescence is azotic gas.

The nitric acid acts upon the urée in three different manners, according to the process which is followed for this action. If we throw highly concentrated nitric acid upon this matter in its solid and crystallized state, a very considerable movement of ebullition is excited; the urée swells much, exhales a very thick vapour into the air, without inflaming, and is found afterwards both in the state of solid and yellowish crystals, and in that of a very brilliant red liquor: the action is so violent that it is not possible to collect the gas.

When we pour weaker, but however sufficiently strong nitric acid, upon a thick solution

lution of urée in water, we immediately see radiated and lamellated crystals, formed of a yellowish white colour, smooth and unctuous to the touch, in great abundance, which almost fill the vessel, and appear to be a combination of the matter little or not at all changed by the nitric acid. The same result is obtained with urine strongly evaporated, and treated with nitric acid a little concentrated. This singular effect, which was before remarked by Mr. Cruickshanks, is so peculiar to the urine, that it characterizes it, and in effect distinguishes it from all other possible matters; it deserves still more to be described and examined with much attention.

Lastly, if we distil nitric acid upon the urée dissolved in water, we obtain by an effervescence which continues for several successive days, an enormous quantity of carbonic acid gas, and azotic gas; Prussic acid gas is also disengaged: the products received into water render it acrid and very pungent. When the matter contained in the retort begins to thicken, it inflames with a violent explosion, and there remains only a light fat residuum, the lixivium of which made with water precipitates the sulphate of iron in the blue state. In this operation the urée is decomposed; it affords much azotic gas and ammonia, which produces, with the nitric acid, the detonation that has been indicated; there is also formed much carbonic acid gas, and a little Prussic acid. A portion

of its carbon is precipitated; the liquid product has a yellowish colour, and is covered with a little oil.

92. The caustic alkalies, whilst they dissolve and soften the crystallized urée, disengage ammonia from it, and at first decompose that portion of ammoniacal muriate, which is contained in it. If we heat a solution of this matter with a ley of pure fixed alkali, much ammonia is volatilized, and the pot-ash is afterwards in quadruple combination with the benzoic and muriatic acids naturally contained in the urine, and with the acetous and carbonic acids, which are formed in it during the action of the alkali and of the caloric upon this matter. If we afterwards distil the urée mixed with alkali which has already re-acted upon it, with the sulphuric acid, we obtain water charged with acetous acid, and a small quantity of benzoic acid. Thus the urée comports itself with the alkalis, as in the slow and spontaneous decomposition, or by the action of a mild fire; we always see it converted into ammonia, carbonic acid, and acetous acid; its constituent principles relinquish their quaternary combination to form several binary ones, and one of these three materials, but always in the same order as has hitherto been observed.

Barites and strontian produce precisely the same effect as pot-ash and soda. Ammonia exerts no sensible action upon the urée. Lime disengages from it the ammonia of its muriate

by simple trituration; if it be very quick, it first absorbs its humidity, with which it becomes heated; afterwards it dries it, and in part effects its decomposition: so strong is the disposition of the urée to pass almost entirely into the state of carbonate of ammonia.

93. One of the most remarkable, of the most singular, and at the same time, the most characteristic properties of the urée, consists in the influence which it has upon the crystallization of two salts contained in the urine. This influence, which chance first presented to Citizen Vauquelin and myself, and which it would have been impossible for us to have discovered without the extensive researches which we had undertaken, upon the urine and its products, is a phenomenon which may hereafter contribute to throw some light upon the knowledge of crystallography. Having very attentively examined some regular octahedral crystals formed in the leys of salt of urine, set to purify, we found that they were composed of real muriate of soda, intimately mixed with a brown colouring matter; on the contrary, cubic crystals, formed in like circumstances, and proceeding from urinary salts, presented to us all the properties of the muriate of ammonia. This kind of reciprocal inversion of the form of the two salts, the first of which is naturally cubic, and the second octahedral, having attracted our attention, and excited our surprise, we thought it incumbent upon us to investigate its cause.

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causes and the circumstances of the variations of form with which saline matters are so frequently affected both in nature and art.

95. Urée unites with many vegetable matters which, like it, are soluble in water; it appears, on account of its great solubility, to be capable of separating from this liquid some of the immediate materials of the vegetables which have less attraction for it than it has itself; such as the insipid mucous and the saccharine substance. For the rest we have as yet very imperfect notions respecting their reciprocal action; we are also ignorant of its manner of acting upon the oils, though it is probable that it renders them miscible with water, and that it is on this account that urine is useful in fulling.

Alcohol easily dissolves the urée, less abundantly, however and less speedily than water does. It dissolves it much more easily with the aid of heat; and as the urée is precipitated from it by refrigeration in the crystalline form, this is the means of obtaining it in the regular form, which we have successfully practised, as I have already said (No. 85). When the alcoholic solution of urée is boiled for some time, this matter is slowly decomposed, a great part of it passes into the state of carbonate of ammonia, which is disengaged and rises in vapour with the alcohol, as it is volatilized. We here see an effect analogous to that of boiling water, and a similar tendency on the part of the urine, to

pass into the state of its accustomed or as it were habitual decomposition.

We know nothing respecting the combinations of urée with other animal substances ; it has not yet been possible for us to appreciate the attractions and the relations which exist between it and those substances : undoubtedly there remain some useful discoveries to be made upon this subject.

96. In the state in which our researches yet are with respect to this urinary compound, though little advanced with respect to what this new career promises to ulterior researches, they are nevertheless sufficient to prove what I have already advanced, that this substance differs from all other matters ; that it is of a very peculiar kind ; that it is a compound in which azote predominates, which presents itself as the ultimate term of animalization, and may be considered as an excrement of which nature must discharge itself, and life must repel far from its focus. The distinct and characteristic properties that lead to this conclusion, are its strong smell and taste ; its disposition to crystallize ; its very easy decomposition by a great number of agents, and always in the same manner ; its conversion into the state of ammonia, of carbonic acid, of acetous and of Prussic acid ; its extreme tendency to the putrid alteration, which it undergoes especially when it is mixed with a small quantity of animal substance extraneous to its proper nature ; and even

even the remarkable influence which it exercises upon the otherwise constant and even tenacious form of two salts, which are not known to vary except with the utmost difficulty.

SECTION VII.

Of the Varieties of the Human Urine.

97. I HAVE hitherto treated only of the urine of the healthy adult, in its most natural, and most common state; but this liquor is not always constant and identical. By considering all the variations of which the urine is susceptible; and are of importance to animal physics and medicine to be known, I find six principal sources of the varieties which affect it, or six kinds of causes which render it different, all of which merit an equal attention on the part of the physiologist. In fact, urine varies, 1. According to the age of the individual; 2. According to the time of the day; 3. In different seasons; 4. According to the aliment; 5. According to the passions; 6. In diseases. Each of these causes influences the nature of the urine in a very peculiar manner. Medicine has indicated a great number of these varieties but only according to the sensible appearances or the external characters. It is for chemical

analysis to determine the real nature of these differences ; but unfortunately it has hitherto done scarce any thing with respect to this important part of physiology. Accordingly, what I shall have to say respecting this subject, will be only a feeble outline of what the art will hereafter possess, a series of views which this kind of research presents, rather than an accurate detail of what it has actually ascertained.

98. The age of the individual has a very decided influence upon the nature of the urine. It has already been remarked that the liquid which the bladder of the foetus in utero contains, is without colour, without smell, and almost mucous. That of infants, in the first years of life, contains no earthy phosphates, and is found to be charged with benzoic acid; it is also little coloured, little odorous, and affords only a small portion of urée. It seems that this excrement is only the product of the vital action arrived at all its force, and of a too great redundancy of animalized matter, which does not exist in young subjects. The phosphate of lime is also not found in it, since there is no superabundance of this in the humours as long as the work of ossification is not completed, as long as the bones have not yet attained their full growth and perfect solidity. The adult in whom those functions are fixed, and who admits a more abundant superfluity of his nourishment, emits a strong urine, charged with salts, with earthy phosphates, with phosphoric acid, with urée

urée and with uric acid, such as has been considered in the present article. In the urine of persons advanced in years, there is frequently conjoined with the urée a nutritive mucilage and a great quantity of uric acid and of calcareous phosphate, with which the osseous system is furcharged : accordingly, they are the most subject to calculi. A comparative analysis of the urine, of the different periods of life, is however still wanting.

99. The time of the day, more or less distant from that of the meals, has also a great influence upon the urine of man. I have formerly distinguished, with the most enlightened physiologists, especially Haller, the urine of drink, the urine of the chyle, and that of digestion, or of coction. The first, which is voided a short time after a meal, is limpid, colourless, and seems to be scarcely any thing more than water ; its abundance, and the short time after drinking that it is discharged, have led some to think that it is the water received into the stomach which passes immediately into the bladder : this is not urine strictly speaking, when it has not the lemon yellow colour. The light yellow colour which it sometimes has, authorizes us to consider it as urine very much diluted, in which the urée is extended with a large quantity of water. Such is generally that which is voided three or four hours after a meal, and which with this character combines that of being frequently charged with the small

smell of the aliments. The urine is not well constituted or completely formed, till seven or eight hours after the meal, and when the distribution of the chyle in the blood is entirely effected, it is then coloured, odorous, aromatic, saline, and charged with urée, like that which has been described in the preceding paragraph.

100. We are as yet far from being acquainted with the influence of the passions upon the variations of the urine: It is only very evident that it is of two kinds; the one, which relates to this liquid itself, such as it is discharged out of the bladder; and the other which is exerted according to the external temperature upon the urine when once discharged out of its receptacles. In general, it is commonly known that the urine in warm weather and in hot climates is highly coloured, very acrid, and produces a burning sensation in the canals through which it passes. This state, which contains more salt, more urée, and consequently less water, is generally attributed to the great evaporation of this liquid, produced by the high temperature of the atmosphere, and to the abundant transpiration which is supposed to exist in these circumstances. In my opinion, it proceeds still much more from the tendency which the humours and the whole animal economy then have to pass into putrefaction, to the excess of animalization which accompanies the high temperature of the atmosphere, and to a greater combustion

voided such red urine that he thought it was blood; but as he experienced no pain nor inconvenience, and had not the slightest symptom of any disease of the urinary organs, Roux on enquiring carefully into the nature of the food and drink which he used, learned that this person had eaten a great quantity of red beet for some days past: and in fact, the mere abstaining from that aliment caused his urine to return to its natural state.

The smell which asparagus communicates to urine, must certainly be reckoned amongst the most extraordinary changes produced upon this liquor by the aliments. Its fetidity is well known; but we are yet ignorant in what this change consists, whether it be a matter added to the urine, and what is its nature, or whether it be only a modification of the urée, or of the other materials of this liquor. The opposite influence which turpentine, the balsams, the resins, and the volatile oils in general exert upon the urine, the smell of which they change into a perfume like that of violets, and with a rapidity of action which always astonishes the observer, is no less worthy of remark. The state of animal physics requires at present that we should not be satisfied with concluding that these substances are diuretic, but that we should investigate, as well with respect to the other kinds of modifications produced in the urine by the aliments and medicines, to what those singular changes are
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to be ascribed. It must be by accurate chemical researches that the cause of these phenomena will be discovered.

103. Even the passions are found to influence the nature of the urine: fright, vexation, grief, and in general, the affections of the mind which agitate the machine, especially sudden shocks, frequently cause an abundant discharge of urine, exceeding in quantity the aliments that have been taken, and voided at the very moment of those affections. This urine is limpid, crude, without smell or taste, and almost entirely consisting of water. This is an effect known to mothers, who, when their infants have experienced a fright from any cause, especially by a fall or a blow, never fail to invite them to make water, knowing well that they are much disposed to do it. It is known that the inclination to drink fresh water is perceived at the same instant, and that it seems as if nature thus impels us to supply the loss of water which the fright has occasioned. This phenomenon takes place even in the domestic animals, which, partaking of our social enjoyments, participate at the same time in our passions and our evils. It is also remarked to be much more frequent and perceptible in their youth than in their adult age. The functions of the kidneys and bladder are as yet too little known to enable us to ascertain upon what this effect immediately depends.

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104. But the, six kinds or varieties of the urine which have just been examined according to the influence of the periods of life, the times of the day, the seasons of the year, the aliments and the passions, are effaced in some measure, and are only slight modifications when compared with those that are the consequences of morbid changes. Here the scenes are much more numerous, the alteration of nature more profound, the varieties of properties more multiplied and more characteristic. Hence it is that physicians after having from the early times of antiquity, acknowledged the importance of this observation, have sought, in the urine of their patients, means of ascertaining the nature of their affections, their progress, and even prognostics of the events that are to be expected : and though on the one hand uroscopic empiricism has almost in all ages laid human credulity under contribution, and though on the other, notwithstanding the multiplied observations of the most able practitioners, the art is very far from having attained to that eminence of which it may be hoped that it may hereafter arrive; its annals already contain a certain number of valuable facts, which when approximated with chemical knowledge, may throw some light upon pathology.

105. When we compare all the facts hitherto observed with the greatest accuracy respecting the morbid urines, and carefully exclude all the general and vague assertions which fill so many works on Symptomatology and Pathology, we find

find eight kinds of urine sufficiently well determined by their marked characters, respecting the knowledge of which the present state of chemistry, and the analysis of this liquid, such as I have presented it, may afford some precise notions, I shall here designate them by their medical names, as they constantly accompany determined diseases or pathological circumstances: those are the inflammatory, the bilious, the critical, the nervous, the arthritic, the calculous, the rachitic, and the diabetic urines. I shall subjoin to the examination of each of these determinate kinds of urine, the enunciation of some other more general pathological modifications which this excrementitious liquor presents, and which, without belonging each to a particular disease, present preternatural properties or alterations, which are met with in several affections, different from each other; so that they are eventual indications or signs, but not constant and pathognomic symptoms: such are the colourless, the red, the green, the turbid, the sedimentous, the glairy, the oily, the sanguineous, the purulent, and the ammoniacal urines.

106. At the commencement of fevers and inflammatory diseases, the patient generally voids a burning, high-coloured red urine, nearly resembling the blood in colour, hot and acrid, and which strongly irritates the canal of the urethra. This kind of urine, called inflammatory has been more especially observed after the

attacks of intermittent fevers. This species of urine does not soon deposit; it does not become turbid by cooling; gives no sediment, and is constantly met with in all cases, in which the temperature of the patient's body is elevated; the sensation of heat energetic; the contraction of the heart, and of the arteries more strong, and the motion of the blood more rapid, than in the natural state. Physicians are well acquainted with this kind of urine; it serves them as a useful indication, especially when associated with other symptoms, for ascertaining the state and the violence of inflammatory affections. When it continues for a long time in these diseases, it is reckoned among the unfavourable circumstances. It has not yet been examined chemically; it may be suspected that the urée is very abundant in it, and still nearer to decomposition, than in the state of health: it is of great importance to confirm this notion by experience; and on this account I would propose a clinical establishment to be added to those which exist; a laboratory, in which the urine of persons labouring under different diseases, should be examined. That of inflammatory diseases, ought to be one of the first subjected to this examination.

107. All the bilious affections, both febrile and chronic, are accompanied, and sometimes preceded by a very remarkable urine, well known and distinguished by physicians, which they call bilious, and which is characterized
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by an orange-yellow colour, resembling the tincture of saffron : imparting the same tinge to the bodies, that are immersed in it, and to the bottom of the vessel in which it is contained. I imagined, nearly twenty years ago, that I had found the bilious colouring matter, in this species of urine ; because having dissolved its extract in alcohol, I had seen this solution precipitated by the addition of water. This fact appeared to me to accord likewise with the notions generally prevalent amongst all medical practitioners, who do not doubt that the colour, and even the matter of the bile may pass by the urine. But other experiments that have since been made, and in cases where in strongly bilious urine, acknowledged as such by able, skilful, medical observers, presented neither the bitterness which characterizes the billiary matter, or its chemical properties, especially the precipitation of its solution in alcohol, by water, which distinguish it, have not confirmed my first result, and have forced me to remain in doubt, respecting the pretended immediate passage of the colouring substance of the bile. The bile has appeared to me, though well distinguishable by physicians, no longer to present its distinctive characters, but consequently to have undergone some alteration, the nature and cause of which cannot be appreciated without subsequent chemical results, obtained by more complete experiments, and a greater number of means, than I have been able to employ.

These researches, as well as several others, of which I shall hereafter speak, enter into the plan of the chemico-clinical experiments above-mentioned. (No. 106.)

108. The most ancient and most constant observations have proved, that at the termination of acute and febrile diseases, at the moment when the amelioration of all the symptoms induces a favourable turn; when the evacuations called critical, accompany this amelioration, the urine is voided more abundantly, and more easily, highly coloured, without being ardent or inflammatory, and deposits as it cools, pulverulent, crystalline, or slightly scaly matter, of a pale red colour, which easily collects and is precipitated to the bottom of the vessel, without remaining long in suspension; this is what is called the critical urine. Scheele says, that the matter of this deposition is uric acid, and that the proportion of this acid is singularly augmented by the action of diseases. In fact, we find in it a large quantity of this acid, but it is not pure: it is mixed with a mucous animal matter, which frequently constitutes a great part of it, and earthy phosphate. This is one of the analysis of the urine, which most deserve to be repeated and varied by different means in the chemico-clinical institution which I propose: since, besides the augmented proportion of uric acid, the cause of which, is of so great importance to endeavour to determine we must likewise distinguish the animal ma-

fation of the attack. He believed, according to this observation, that the pain of the gout was occasioned by the regurgitation of the acid phosphate of lime, which irritated the membranes and the articulations: however, the nature of the arthritic concretions does not correspond with this notion, because they are not found of the same substance. For the rest, the absence of acidity, and of the phosphate of lime, which cannot be doubted in the gouty urine, may be a necessary state, simply concomitant of the arthritic affection, without being the cause of it; perhaps there may be a still more immediate relation between the deposition of urinary calculi, and the attacks of the gout, since long experience proves that the formation of calculous concretions frequently succeed arthritic pains; new researches therefore remain to be made respecting those relations, and their mutual influences: they require the precision and accuracy with which these investigations are at present generally conducted.

111. The urine voided by rachitic patients, at the time when their bones become softened and deformed, is frequently charged with phosphate of lime, and deposits a large quantity of it by cooling. It is easily perceived by an attentive observation of the principal circumstances of this disease, that a great operation goes on in the whole osseous organ; that this system undergoes a real decomposition; that its calcareous phosphoric part is dissolved; that

that its gelatinous part becomes insulated and inflated; that the solution of the phosphate of lime is effected by an acid, and that it is carried abundantly into the urine. An examination of this liquid, in well marked cases of rachitic, may throw great light upon the phenomena of this terrible affection, which attaches itself to the first ages of man, and leaves during his whole life, traces of its ravages, and frequently even dangerous remains of its virulence. Citizen Bonhomme, of Avignon, in a very good memoir which obtained one of the prizes of the ancient society of medicine, upon the rickets, asserts, that the softening of the bones in this disease, depends upon the presence and the action of the oxalic acid, generated in the bodies of infants, by the debility of their organs, the weakness of their stomach, the feebleness of their digestion. If this notion, which the author has not yet well proved, be just, its confirmation will be found in the nature of the urinary deposition, which must be oxalate of lime; and this might explain how the calculus of the same nature, of which we shall speak in the following article, is formed in the urinary passages. Citizen Turquais, a medical student in the school of Paris, has already communicated to me, an observation respecting the urine of an infant that died of a disease originating from worms, which became turbid almost immediately after it had been evacuated, and the sediment of which, exhibited to him -

in its analysis, all the characters of oxalate of lime: it is evident, to how many valuable researches the examination of the urine of rachitic patients may give occasion.

112. There are two sorts of diabetes, or of immoderate evacuation of urine; with relation to the nature of this liquid: in the one, which appears to be the most frequent, the urine is colourless, white, insipid like water, and seems to have all its characters; this disease is generally accompanied with a great thirst, with rigours, and with a general coldness of the body. The other species consists in the discharge of an abundant urine, of a saccharine taste; on which account it is called the *diabetes mellitus*, or the saccharine diabetes: this, which is much more rare than the former, has been several times observed in England, and described with much attention, both with respect to the diagnosis and the symptoms, in its cause and its treatment, by Dr. Rollo, an English physician. By evaporating the urine of the latter, an extract is separated from it, which is sweet, like honey, and presents many of its properties. Cullen had before observed it in the hospital of Edinburgh, and he obtained this saccharine matter by evaporation. There is reason to believe, that in this case, this matter supplies the place of the urée that is wanting, and that then the liquid of the kidneys has not really the properties of urine. It is so an alteration in the digestion, that Dr. Rollo ascribes the
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production

production of this singular disease; according to him, there is formed in the stomach, a real mucoso-saccharine substance, which, on account of its abundance, passes off by the urinary passages. I have already observed, in the article concerning the milk, that with females that give suck, the matter which is called the sugar of milk, is formed by digestion, and that the nurses are in a state, analogous to that of persons labouring under the saccharine diabetes it is possible that a saccharine character may be found in their urine, especially under some circumstances, when the milk is determined less towards the breasts. This is another subject of the most important and most useful researches for the progress of the art; and it is to those who are much conversant with women that give suck, that it ought to be presented and recommended.

113. Diagnostic and prognostic symptoms have frequently been derived from the colour of the urine in diseases; and though strange abuses have been committed, respecting the variations of this character, which, alone, and without other indications, generally present only a source of illusions, errors, and uncertainties; it is, nevertheless, accompanied with some circumstances, the relations of which with the state of the animal economy, are essential to be known. In general, a natural state of the urine in an otherwise severe disease is an alarming symptom. We have already
seen

seen in what cases the urine is white and colourless, as well as what this indicated; I have likewise spoken of the red, ardent, inflammatory urine. Green or blueish urine has sometimes been observed with or without sediment. Sometimes, though still more rarely, this liquid is of so dark a colour, that it appears to be black. In these cases, the defect is generally ascribed to the thickened bile, and even the atrabile or melancholic humour, conveyed to the different reservoirs. As we have no accurate notion concerning the atrabile, it is evident that nothing can be said respecting the green, black, and atrabilious urines, without having examined them chemically. It is however well known in practice, that these kinds of urine are very unfavourable, and that they indicate the greatest danger, in the cases in which they are observed. It is evident, how much light a well made analysis of this liquid, thus altered, must diffuse over pathology.

114. I have already spoken of turbid urine, which must be well distinguished from the sedimentous. The first is evacuated with a precipitate already formed, and frequently announces a degeneration, or alteration, which depends upon diseases of the urinary passages or organs: the sedimentous, which do not deposit till after they have been evacuated, and are not properly critical urines, in which a light homogenous precipitate, of a rose or lilac colour, is formed, and held for a long time suspended

suspended, are oftener met with in the chronic diseases; their deposition is composed of earthy phosphates, and depends chiefly upon the state of the bones, of the articulations, of the membranes, and of the muscular and sensible organs. Those kinds of urine merit all the attention of physicians, and ought, in what disease they present themselves, to be subjected to an accurate analysis.

There is known in medicine, a glairy, turbid urine,ropy throughout its whole mass, or in some parts of it; sometimes more or less flakes are separated from the urine and deposited, and adhere more or less strongly to the sides of the vessel. Both these urines generally accompany the diseases of the bladder, and it is thought that the kind of mucus which separates from them, proceeds from the membranous and sensible sides of this viscus.

As to the oily urine, which is extremely rare and perhaps never actually exists, it is considered as the strongest proof of an inveterate acrimony or advanced decomposition of the humours. There is reason to believe, that the urine which has been designated by this name, on account of a slight stratum of a greasy appearance, is not really oily; but that the superficial layer which has been taken for oil, is only the duct of a saline evaporation, as we see in many chemical solutions, the surface of which

sents, by the contact of the air, a small portion of their salt separated from the liquor.

115. The urine is sometimes sanguinolent, or mixed with a more or less abundant quantity of blood; frequently this liquid is separated and deposited at the bottom of the urine, in the form of blackish brown flakes, which are gradually discoloured and dissolved, becoming reduced into white flakes, similar to a thick glairy matter. Great care must be taken not to confound the sanguinolent urine, either with that which is coloured by the abundance and acrimony of the urée or of the uric acid, or with that which has taken a colouring matter from any aliment, or medicine, such as beet-root, or madder. The urine charged with blood, proceeds in general from an affection of the kidneys, of the ureters, or of the bladder, which almost always depends upon a laceration of the vessels, produced by the presence of a tuberculous or spinous calculus. Sometimes, however, the blood in the urine proceeds from a deviation of another sanguinous evacuation, such as the menstrual or the hemorrhoidal discharge. The latter is distinguished by its being voided without previous pain, and with the signs of the suppression of the menses, or hemorrhoidal flux, whereas the sanguinolent urine proceeding from a defect of the urinary organs, is preceded by acute pains, and not by suppression of other evacuations.

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The purulent urine, from which the pus is voided with it separates and is precipitated in a thick liquid, of a white or greyish colour proceeds also from a disease of the urinary organs, and an alteration in some of their regions. Sometimes, this liquid is so much altered by long continued diseases of the bladder, and the time which it remains in it, as to be voided in a fetid and ammoniacal state. This is one of the characters which the urine of calculous patients easily contracts, especially with old persons labouring under these affections. It is sufficiently distinguishable by its strong smell; instead of being acid like healthy urine, it turns the blue vegetable colours green.

SECTION VIII.

Of the Varieties of the Urine in the different Animals.

116. **THOUGH** the urine has hitherto been presented as a liquid of a particular nature, and characterized by properties which exclusively belong to it; though we may even represent to ourselves, according to these notions, the urine of the different animals as approaching in a remarkable manner to the nature of that of man, especially by the presence of the *urée* which gives it its specific characters of an excrementitious humour, and, as it were, an ultra-animalised matter; there must, however, exist in this liquid, considered in the different classes of animals, differences inherent even in their nature and the diversity of their organs, of their nourishment, of the medium in which they live, of their mode of respiration; all which circumstances, as I have shown, influence its properties. And in fact, notwithstanding the small number of researches that hitherto exist in this respect in the annals of the science, no constant results have already presented themselves to chemists in the first labours of this kind which they have undertaken: the *urée*, that the urine of every terrestrial quadruped,

ped, or mammiferous animal contains the specific urinary principle or the urée, which gives it its true nature; the other, that it is in the number, the proportion, and the different species of the saline substances which are dissolved in it at the same time, that the differences which this liquid exhibits alone consist. Indeed we have hitherto examined only the urines of the horse, of the cow, and of the camel, the analysis of which has been described in 1773, and 1777 by Rouelle, the younger. But besides that of the horse, which Citizen Vauquelin and myself have repeated, and in which, together with the principal characters of that of man, we have found something more than this able chemist had done; besides the striking analogies, which these three kinds of urine, already well known, present with each other, and with that of man: some facts which we have hitherto been able to collect upon the urine of the hare, of the guinea-pig, of the cat, and of the tortoise, assure us still more of this analogy, and afford me the means of beginning at least to establish the comparative history of this liquid in the different orders of animals.

117. The following are the properties which Rouelle had described in 1773, in the urine of the horse. It has a strong peculiar smell, analogous to that of the urine of the cow. It is discharged in a turbid state or quickly becomes so after it has been voided; its surface exposed to the air becomes covered with a pellicle similar

the cream of lime, which is renewed when it is broken; this pellicle amounts to one-fifth of its weight. A gelatinous sediment is deposited from it which renders this urine ropy; this property is destroyed by agitation and filtration; it turns the syrup of violets green, effervesces with the acids, and is precipitated like lime-water by the alkaline carbonates. There is obtained from it by analysis an extract and a saponaceous matter the urée, common to the human urine; the saponaceous matter is pretty abundant in it; the extractive is less so than in the human urine; it is blackish. He obtained from these two substances the same products as from those of the urine of the cow, but no muriate of ammonia nor phosphorus, as from the extract of the human

Their residuum contains pot-ash, they contain a little from the same matters extracted from the human urine. The urine of the horse contains no phosphorus: it contains sulphate and carbonate of pot-ash in considerable abundance, and a saponaceous carbonate soluble in the acids, which is converted into lime by a strong fire, and is precipitated into glass by the heat used for porcelain; the extract of lime which is precipitated with the tartaric acid is a fine earthy salt. He found in it no indurated pot-ash as in the urine of the cow. It effervesces, however, in its putrefaction the same as the urine of man and of the cow; the matters which it contains are not altered; but in the extractive and saponaceous matters

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that the putrid alterations take place. Rouelle promised to ascertain them by new observations but he published nothing upon this subject from 1773 till his death, though since the above mentioned period he has several times spoken of the animal matters and especially the urines.

118. In analysing the urine of the horse more than twenty years after Rouelle, we have confirmed most of his results, and have added to them several new facts. I shall here give an account of our labours, in order that they may be compared with those of the illustrious chemist who had preceded us in this career. The urine of the horse, at the moment when it is voided, has the smell of hay mixed with that of transpiration; it is ropy like a solution of gum, it is bitter and saline, and afterwards a little saccharine; after violent exercise, it is turbid and white like milk; that which is voided in the stables and pastures is discharged clear and becomes turbid by cooling; its specific gravity is between 1,030, and 1,050. It turns the syrup of violets green; it effervesces with acids, and precipitates the nitrates of mercury and of silver, and the muriate of barites; oxalic acid forms in it an abundant precipitate as well as lime-water and the caustic alkalis. The solid pellicle which is formed at its surface by the contact of the air, amounts to between 0,002 and 0,011 of the weight of the urine; it contains a vegeto-animal matter with carbon.

carbonate of lime, which constitutes its base ; for it becomes black upon ignited coals, yielding a vapour of pyromucous acid and ammonia ; it froths and becomes covered with a scum in the acids. At the same time that this pellicle is formed, the urine of the horse becomes coloured, and brown by successive strata from the top to the bottom ; which does not happen to it in close vessels. Evaporation likewise colours it ; when it is reduced to a fourth of its volume, there are formed in its surface cubic, saline, pungent crystals, that weigh nearly 0,5 of the urine. The concrete residue of the evaporation dissolves almost entirely in alcohol, and frequently leaves undissolved carbonate of soda. The alcoholic solution affords by evaporation crystals of muriate of pot-ash, and afterwards a second salt, which is brown and acrid, and has been ascertained to be benzoate of soda ; from the solution of which in water, benzoic acid has been precipitated by muriatic acid ; this same acid is also found in the urine of the horse : treated alone by the muriatic acid, it is separated from it in crystalline needles in the course of time ; it amounts to 0,011 or a little more than 0,01 of the whole. When the alcoholic solution of the extract of the urine of the horse has yielded the muriate of pot-ash and the benzoic acid by the addition of the muriatic acid, it yields by evaporation an oily pellicle of muriate of soda : reduced to the state of syrup, it

concretes by cooling into solid and crystalline urée.

119. According to the analysis the processes of which I have just enumerated, the urine of the horse has appeared to us to be formed of carbonate of lime and of soda, muriate of pot-ash and of soda, of benzoate of soda and urée; it was even in this urine that we first recognized the urée as a peculiar matter, by its property of being precipitated in dense and compressed crystals from the inspissated urine by the aid of the nitric acid. We found it in the human urine and afterwards in the urinous liquids of some other animals after we had discovered it, as a peculiar matter, in that of the horse.

We did not content ourselves with thus ascertaining the differences which exist between the urine of the horse and that of man, both taken in their sound and natural state; but we pursued our examination of the first urine when altered by spontaneous decomposition. In this state it presented to us a dark and almost black colour, and a very strong ammoniacal smell; the acids precipitated benzoic acid from it with a brisk effervescence. It contained no more carbonate of lime; it yielded by distillation water charged with carbonate of ammonia, which acquired a rose colour by the addition of the acids; after this operation it effervesced no more with the latter; during its evaporation there was separated from it an
oily

oily, acrid and black pellicle. Its extract being dissolved in alcohol, there remained acetate of ammonia, and the solution yielded muriate of pot-ash and benzoate of soda; the muriatic acid disengaged from it acetous acid, separated from the benzoic acid, and the addition of the nitric acid did not form in it those white silky crystals, which it separates in abundance from the fresh urine of the horse. Thus the differences observed in this fermented urine are reduced to the absence of the carbonate of lime, of that of soda, of the urée, and the presence of the acetous acid and the carbonate of ammonia. The last does not exist in this urine when not altered, and it is one of the principal products of its fermentation. The carbonate of soda is decomposed in it by the acetous acid, which seizes upon its base, while it unites also with the ammonia. These saline combinations oppose the disengagement of gas during the fermentation of the urine. This spontaneous movement in it is owing to the urée, like that of the human urine, and this urinary matter is converted into ammonia, acetous and carbonic acids—a conversion which gives rise to all the changes produced in this liquid.

120. Rouelle is the only chemist who has examined the urine of the cow. His enquiry published in 1773 in the *Journal de Médecine*, contains the following principal facts which establish a great analogy between this urine and

and that of the horse. The urine of the cow is unctuous to the touch, and has a strong and peculiar smell. Its colour grows darker by keeping; it never has the fine amber tinge of the human urine; there are formed at its surface, that is in contact with the air, in eighteen or thirty hours, small oblong crystals with regular faces. In two or three days, it deposits a gelatiniform sediment. It turns the colour of violets green; it effervesces with the acids; it is not altered by the alkaline carbonates. It contains carbonate of pot-ash, which is the cause of its effervescence: by adding to it weak nitric acid and afterwards evaporating it, we obtain from it needled crystals of nitre. We also find in it, as in the human urine, two substances the one called saponaceous, the other extractive. The first, or the urée, which is very abundant, is soluble in alcohol, affords much ammonia, by the fire, with more oil than that of human urine; but no ammoniacal muriate. Its coal is alkaline and effervesces with the acids. The extractive matter is more abundant in it than in the human urine. It affords the same products as the saponaceous. Both are, according to Rouelle, a little different from those of the human urine. Besides these first bodies, the urine of the cow contains sulphate of pot-ash in considerable abundance, muriate of pot-ash and an acid analogous to the benzoic, soluble in alcohol, and which the author has believed to be decomposed by putrefaction, as he did
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ad it again after this alterative move-

He pretends also that this volatile which he does not positively assert to be as the benzoin, does not constantly in the urine of the cow. He asks whether it does not depend upon some circumstances relative to the nourishment or the drink of the animal. He concludes with asserting that this does not afford phosphorus, and contains no phosphate. He had promised several other experiments respecting this urine, which he has not performed, and which certainly have not been published in his papers, as nothing has appeared since his death.

However, three years and a half after the publication of those interesting analysis of the urine of the horse and of the cow, Rouelle, Junger, gave in the *Journal de Medicine*, 1777, some observations upon the fresh and putrefied urine of the camel. He examined it two or three hours after it had been voided. According to his examination, this is of a dark ale-colour and a little turbid, more odorous than any other, but nevertheless inferior to that of the cow, though very different from that of man and of the horse; not muciliginous, and does not deposit carbonate of lime like the latter. A vessel containing one ounce of distilled water contained 1 ounce 3 grains of the urine of the camel, 1 ounce 1 grain of that of the cow, 10 ounces 1 grain of that of the horse, and 10 ounces 15 grain

15 grains of human urine: thus the urine of the camel was the heaviest of all. It slightly turns the infusion of violets green, effervesces with the acids, affords nitre, sulphate, and muriate of pot-ash by the addition of the nitric, sulphuric, and muriatic acids, and by evaporation. It affords by evaporation on the water-bath one ninth of its weight of an extract in a firm mass; a quantity more considerable by one third than that of the extract obtained from the urine of the cow. He concludes his examination with saying that the urine of the cow contains the two substances, the saponaceous and the extractive; that the latter is more abundant in it than in the human urine, and thus it resembles that of the cow; and that there are also found in it sulphate and muriate of pot-ash, besides free pot-ash. As to the volatile salt, he had not discovered its presence, and he admitted it to exist in it only by reason of the great analogy which he had found between this urine and that of the cow, inasmuch that he thought it difficult to distinguish them. At the end of this short notice respecting the urine of the camel, he says that its coal, burned and lixiviated, affords about $\frac{1}{11}$ of the weight of the urine, of saline matters, and he remarks that the muriate of ammonia which he did not find in this liquid, could not actually exist; it is along with the fixed alkali, and that it is consequently not from this excrementitious humour that the sal ammonia of Egypt is obtained,

obtained, for the fabrication of which Haffelquist, indeed, assures us that they do not employ the urine of the camel.

122. The urine of the rabbit, which has been examined by Cit. Vauquelin, presented to him remarkable analogies with that of the three great mammiferous animals of which we have just been treating. This urine is turbid and becomes milky by cooling ; it becomes brown in the air and ferments ; it turns blue vegetable colours green, and effervesces with the acids ; it precipitates the nitrate of silver, the muriate of barites, and the magnesian salts. Its sediment, dissolved with effervescence in the nitric and muriatic acids, leaves a small quantity of sulphate of lime and is precipitated by the alkalies. After fermentation it has a strongly ammoniacal smell ; it is precipitated also by the gall-nut, but less abundantly than when fresh. The fermented urine of the rabbit, when evaporated, exhales much ammonia, gives an oily pellicle at its surface, leaving blackish residuum from which alcohol takes up the coloured part and separates a saline portion. The presence of the urée is not so sensible in this urine as in the preceding kinds, and it appears to undergo a more profound or more complete alteration by fermentation, as it cannot be sensibly precipitated by the nitric acid. The saline portion not dissolved by the alcohol, is a mixture of carbonate of pot-ash and of sulphate of pot-ash ; the muriate of pot-ash and the acetite of
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of ammonia, united with a colouring matter, are in solution in the alcohol, which presents the first by evaporation, and the second by distillation. Citizen Vauquelin gives, as the result of his analysis, that the urine of the rabbit contains a very alterable urée, a gelatinous mucilage, carbonate of lime and of magnesia, carbonate of pot-ash, sulphate and muriate of pot-ash, and that there is formed in it by fermentation, acetous acid, carbonic acid, and ammonia: he has not indicated the benzoic acid undoubtedly on account of the small quantity of this urine, which he was able to examine; neither has he found any phosphates in it. He admits a small quantity of sulphur in it, and he remarks, that it frequently exhales a very sensible smell of the vegetables, with which the rabbits have been fed. It cannot be doubted, according to this analysis, that there are very great analogies between this urine, and that of the horse, of the cow, and of the camel. The constant abundance of the urée; the presence of the carbonate of lime and of pot-ash; of the muriate and sulphate of the same base; the absence of the phosphates and of the uric acid; the property of being converted into ammonia, and into acetous acid, by fermentation; these are so many characters by which this liquid approaches on the one hand, to the urine in general, as a peculiar animal humour; on the other, to that of the hairy herbivorous animals, in particular.

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rejected by this excretion ; but this rejection is not to be considered as the principal ; and still less, as the only utility of the urinary discharge, as was done some years ago by physiologists. It is true, that at that period, the constituent materials of the urine were but very imperfectly known, so that it was to the marine salt, that its saline nature was almost exclusively attributed, and Stahl even maintained, that the phosphorus obtained from its extract belonged to that salt. It is now known that the phosphates of soda, and of ammonia, are more abundant than the muriates of the same bases in the human urine ; and that it is for their evacuation that nature has at the same time designed to provide, since the urine is always charged with them. In this kind of excretion, there is a great difference between man, and the frugivorous mammalia : the urine of the latter does not contain alkaline phosphates, and the kidneys in them are not the emunctory of those salts ; but the hair which covers their skin, the corneous appendages which defend their extremities, even their sweat, afford the means by which the phosphoric acid is exhaled ; indeed under another form of combination. Their urine being more analogous to the nature of their nourishment, is more alkaline than acid, and potash supplies in it, the place of the soda, of which a pretty considerable quantity is found in the human urine.

129. The phosphates of lime, and of magnesia, are peculiar to the human urine; and nature, having intended these salts to be evacuated by the way of the kidneys, has rendered the former especially soluble in their liquid, with the aid of a small excess of phosphoric acid. As nothing similar is found in the animals, it is evident that one of the most important utilities of the human urine, is to evacuate the superabundance of the calcareous phosphate, or earth of the bones. Accordingly, its proportion in this urine, is always relative to the state of the ossification: there is little or none of it in the first age of life, in which the bones are formed, and employ all the phosphate of lime taken in with the nourishment: it augments in proportion, as the bones grow harder; it is at its maximum, when these have attained their full growth; it increases, when the bones become softened in various diseases; and at all times, the knowledge of it is of importance to physiology and medicine. Instead of this salt, the principal source of the white sediment, which is formed in the human urine, that of the mammalia contains carbonate of lime, which is also precipitated from it; and in the animals, the superfluity of phosphate of lime is conveyed into the hairs with which their skin is provided; into their nails; into their horns; into the different exterior appendages of their body, and even into the abundant sweat, which violent exercise occasions in them.

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130. If we consider the great quantity of animal matter, peculiar to the urine, which I have designated by the name of urée; if we recollect, that it exceeds by several times the sum of all the other saline bodies dissolved in this liquid; that it gives it its colour, its smell, and its real urinary character; that without it this liquid would not be what it is; that it has been constantly found in all kinds of urine hitherto examined, it cannot be doubted that its expulsion is the principal end, the most necessary, and most remarkable purpose of the urinary evacuation. When we afterwards behold it so soluble, so alterable, or fermentescible, more especially so subject to be changed by the variation of equilibrium into carbonate of ammonia, we can no longer doubt that it is an animal matter, compounded by the vital action of the organs, carried to the last term of complicated combination, disposed by a powerful and long chemical attenuation, to separate into its first elements; in a word, a too much animalized body, carried to the *maximum* of animalization, not susceptible of undergoing any more intimate alteration, without being decomposed and destroyed, and consequently menacing the animal organization, with an impending solution and destruction, and requiring to be evacuated by the preservative power, which presides over the support of life. Accordingly, this matter is surcharged with azote and hydrogen; and we might affirm that the too highly vitalized portion

of the blood being carried to the kidneys, is separated in their intimate texture, into two new materials, the one highly oxygenated, or the water, and the other highly azoted; the first, returned to the binary combination, which so constantly accompanies the last decomposition of the complicated compounds; the other, assuming at last the extreme and least permanent character of animalization, which renders it so quickly and so easily destructible. Thus the urine being charged with this principle, which it causes incessantly to pass out of the body, carries off the most exalted animal matter; the most dangerous ferment for the other humours; the source of a putrefaction, which would loosen, and even break the thread of life, if it were retained within the body. What important views does this consideration present to medicine, and what useful results may it not furnish to the art, when the nature of the urine in putrid diseases, shall be studied?

131. The uric acid is also one of the excrements, which the urine constantly carries with it, and if we except the deposition of the bladder of the tortoise, which has presented it to Citizen Vauquelin; it appears, that the urine of man alone contains this acid matter; the most common source of the calculi of the kidneys and of the bladder; for no uric acid has hitherto been found in the urine of the other animals. However it is probable, that this acid has intimate relations with the urée, though
chemical

chemical means have not yet succeeded in establishing them with precision. How does it happen, that the urée which is very abundantly contained in the urine of the mammalia; never passes into the state of uric acid? Why is this acid constant in the human urine? How is it produced there, and what particular circumstances gives rise to it in man, whilst it does not exist in the mammalia, which are otherwise so similar to man in their structure? All these are questions, which it will be possible to solve only by carefully following up that description of chemico-clinical researches, of which I have spoken above, and which certainly afford us ground to hope for their solution by these researches. The interest which they ought to excite, is founded both upon the exclusive constancy of this acid in the human urine, and upon its varied proportions in the different conditions of the animal economy, especially at the end of diseases, as well as upon the relation which appears to exist between its discharge by the bladder, in the healthy state, and its transportation towards the articulations in gouty affections of which its retention and metastasis seem to be the immediate cause. For the rest, I shall speak again of this subject in the next article, and I shall return, under other points of view, to the useful considerations, which this yet very new matter requires.

132. It must be already evident, how great an influence the chemical examination of the urine must

must have upon the human physiology ; how much greater will it appear, when I shall be able to cause this liquid to be considered as a critical evacuation, in a great number of diseases ; as replacing other evacuations in a great number of cases, or corresponding in its abundance and varied nature with the diminution, the augmentation, and even the variations of other natural discharges when I shall show, that by the changes of its properties, it becomes a source of more or less certain indications for appreciating what happens in many diseases ; that by becoming charged for example, with nutritious animal matter, either albuminous or gelatinous, as appears to take place in obstructions of the abdomen, rickets, scrophula, diseases of the stomach, phthisis, &c. instead of evacuating the urée, the last term of animalization ; the urine, in this preternatural state, furnishes the physician with the means of estimating with precision, the debility of the assimilating organs ; the deficiency of nutrition : the aberration and the ever dangerous discharge of the alimentary juices ; when, finally, according to the different changes which affect it, I shall find in this liquid, examined with more attention than is generally done by mere inspection, a multitude of indications adapted for determining the presence, the characters, and the various states of so many morbid affections. It will undoubtedly be admitted, according to this slight sketch, that if there still remain many researches

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to be made on this subject, they promise so many advantages; so many applications of immediate advantage to animal physiology, and already so superior to those which could formerly be exhibited, that the influence of chemical knowledge, upon the rapid progress of this physiology can no longer remain problematical.

SECTION X.

Of the Chemical and Economical Uses of the Urine.

134. THE very remarkable characters, and especially the pungent and acrid taste, as well as the strong odour which the urine exhales, which so eminently distinguish it from every other known substance, though it has hitherto always been unknown what was the origin of it, have long since caused this liquid to be ranked amongst the medicinal substances, and even amongst the most heroic remedies. Its medicinal qualities were especially attributed to its saline nature; it had even been recommended in severe diseases, in which other remedies generally fail. Thus it passed for a kind of specific in the obstructions of the abdomen, and of the liver, in the rickets, in obstinate ulcers, and in intermittent fevers, that resisted

resisted other modes of treatment. It has even been ranked amongst the most efficacious anti-epileptics, aphrodisiacs, hydragogues, and anthelmintics. Notwithstanding the high opinion which some professional men have entertained of the medicinal properties of the urine, and the encomiums which have been bestowed upon them, skilful physicians have long since renounced its use; and at present we see only some ignorant practitioners, some impudent empirics, prescribe this remedy, or some of the country people take it of their own accord, and administer it to their children.

134. The internal administration of urine, ought not however to be considered, either as an object of indifference to the art, or as a futile and ineffectual practice. Admitting some successes that have been obtained with it, but which have undoubtedly been too much boasted of, and which have taken place in difficult or desperate cases, several facts prove that urine has produced more or less violent affections, vomitings, strong diarrhoeas, even acute pains and effects, almost equal to those of poisons. When we know the nature of the urée, we cannot deny, nay, we must even naturally conceive the possibility of this action of the urine. A matter so putrescible, so acrid, so nearly approximating to decomposition, carried to an excess of animalization, which renders it so fermentescible, may, nay must, by eluding the digestive power of the gastric and intestinal juices,

juices, give rise to more or less perturbation in the living animal economy. I am even inclined to believe, that if an inconsiderate use were made of it for a continuance, and in too small doses for it to act very sensibly alone, it would gradually debilitate the vital powers, dispose the humours to septicity; that it might give rise to putrid diseases, and threaten the animated machine with complete dissolution. The prudence of physicians, which has long since renounced the employment of the urine, as a medicine, and which certainly is founded upon enlightened experience, is laudable and fortunate for the human race; and it must be left to quacks, to employ a medicine, the disgusting qualities of which, as we see, are not the only inconveniences which patients have to apprehend from its use.

135. The employment of urine, as a topical remedy, in a great number of external affections, is still much more frequent, and is not indeed accompanied with the same dangers, or the same causes of apprehension. It is used in cases of burns, contusions, cold humours, and lymphatic congestions; it is thought to possess a strong attenuant power; it is frequently associated with farinaceous substances and emollient herbs, for cataplasms and liniments of different kinds. It has been especially recommended for the burns produced by inflamed phosphorus, and chemists have announced it, as being almost a specific in this case. This can only be

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on account of the discutient and repulsive quality that has been observed in it. Some have also recommended its application to parts affected with gout and rheumatism; but its use may not be indifferent in this case, and I think it more prudent to abstain from it, in all cases; it ought never to be employed without precaution; and too much attention cannot be bestowed upon observing its effects. Recourse should be had to able men, well skilled in the practice of the art, for directing its employment, and moderating its activity.

136. The chemical uses of the human urine, are much more certain, and more to be recommended than its medical applications. Though this was the first substance from which phosphorus was extracted, it has not been employed for this purpose, since 1774, the period when Scheele and Gahn discovered the extraction of that combustible body, from bones. However, with the aid of some chemical preparations, we may still avail ourselves with great advantage of the phosphates contained in this liquor, for obtaining phosphorus from them. When fresh urine is precipitated with the nitrate, or acetite of lead, a deposition is formed of insoluble phosphate of lead, proceeding from the decomposition of the three phosphates of the urine; this salt, collected, very carefully washed, and immediately distilled with one-fourth of its weight of charcoal, easily yields phosphorus. The colouring matter, or the urée
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and the uric acid, which are deposited in part with the phosphate of lead, do not impede the success of this operation; they only render the products complicated by the carbonate of ammonia, which they furnish, and contaminate the phosphorus a little by the oil which they yield in their decomposition by the fire; but the volatile saline product remains in solution in the water, in which the phosphorus comes over and is received; this is pretty easily purified, either by distilling it with a gentle heat, or by pressing it several times successively under water, through a chamois-skin. The muriate of lead, which also accompanies the precipitate, may be separated by washing with large quantities of water, especially when the water is sharpened with a little muriatic acid. This fabrication of phosphorus may be practised with advantage in houses where a great number of persons are collected together, by carefully accumulating their urine in troughs, precipitating it every day with a soluble salt of lead, and collecting the precipitate, till there is a sufficient quantity of it to be subjected to distillation. The apparatus of Pelletier, may be employed for this purpose. The salts of zinc may be substituted instead of those of lead; but they are dearer than the latter, and could only be employed in places where they were very abundant.

137. Another chemical use of urine, which is not confined to that of man, but belongs

longs equally to the urine of all animals, is the production of ammonia. By evaporating the liquid to the consistence of an extract, and distilling it in proper apparatuses, a large quantity of ammoniacal carbonate is obtained. Haller has long ago indicated this useful application of the properties of the urine. It was formerly, proposed to employ this product in medicine, and valuable properties were attributed to it; at present we are better instructed upon this subject, and know that this carbonate of ammonia does not differ from that which is obtained from all the animal substances; but that when well purified, it is the same, from whatever substance it has been obtained, and that it is of much greater importance, to consider its abundant production from distilled urine, for the uses of the manufacturers in the fabrication of ammoniacal muriate, than for medicinal preparations. Thus, for example, it would be useful to combine with the operations of the salt works, where the mother-waters contain muriate of lime, the extraction of the carbonate of ammonia, by the distillation of putrefied urine. This product, united with the mother-waters, from which it would separate carbonate of lime or chalk, would leave dissolved in it, muriate of ammonia, and this would be obtained by evaporation. We might also precipitate, by the ammoniacal product of the urine, a water charged with sulphate of lime, or this salt simply diluted in water, extract the

4 sulphate

sulphate of ammonia, thus formed, and heat it with muriate of soda, in order, by the action of the elective attractions, to sublime from it, ammoniacal muriate.

138. Citizen Vauquelin and myself have indicated the urines of cattle, as proper for furnishing benzoic acid; and this is another chemical use to which they may be applied. For this purpose, we should evaporate these urines a little, pour into them muriatic acid, sufficiently concentrated, and wash the white crystalline precipitate of benzoic acid, which is obtained from them. A preliminary experiment should also be made of the urine of the mammalia, that is destined for this operation; for it is possible, that, according to the aliments with which the beasts are fed, that the liquid may contain too little of this acid, for it to be extracted with profit, though I do not think this circumstance frequent enough to oppose any obstacle to the extraction of the benzoic acid; the urine which has remained in the litter, and runs off at the bottom of the dung-heaps, may also serve for the same operation.

139. The employment of urine, in the artificial preparation of nitre, is another of its most important uses; it contains a sufficient quantity of animal matter, to favour the production of nitric acid in putrefaction. But that of the mammiferous animals, is in this respect, greatly preferable to that of the human species. The latter contains muriate of soda and phosphates,
which

which render the portion of saltpetre, which is formed in it, both very impure and very scanty that of quadrupeds, on the contrary, has over the human urine, the great advantage of being charged with pot-ash, and muriate of pot-ash; and in proportion as the nitric acid is formed, it is converted into sufficient pure nitre; the portion of nitrate of lime, which is formed, is also decomposed by the muriate of pot-ash. On this account, the herdsmen of Switzerland extract an abundant quantity of very fine saltpetre, from the putrefied litter of their cattle, and from the earth under their stalls. In Denmark, all the farmers form artificial saltpetre-beds with the dung of their cattle, which they mix with sand, and leave to be slowly decomposed.

140. Human urine has been employed from time immemorial, for fulling and cleansing of wool. The fullers and dyers of Rome, who by a decree of police, were banished from the city to the other side of the Tiber, preserved the urine in large earthen vessels, in which they suffered it to putrefy, as Martial informs us, in several of his epigrams, where he inveighs against the nauseous smells proceeding from their workshops; it is still employed in some countries for similar uses. The human urine enters also into several compositions for dying. With it, and by maceration, are prepared the red colour of archil, and several other colouring matters, with some species of lichens, the *rocella*, the *parellus*, &c.

ARTICLE XXVI.

*Of the Urinary Calculi of the Human Species,
and of the Arthritic Concretions.*

SECTION I.

*Of the successive Inquiries that have been made
respecting Urinary Calculi.*

1. **THOUGH** the urinary calculi, which are formed in the human kidneys and bladder, are only morbid and preternatural concretions; yet as the materials of which they are formed, are almost all contained in the urine of healthy subjects; and as their study, by throwing light upon the means of opposing their formation, or effecting their solution in the bladder, may render the very important history of this excrementitious liquor still more complete, I have thought it proper to treat of them after the history of the urine. I have besides been induced to do so, by the interest which this study must have in the chemistry of the physiology of animals; especially since the last discoveries made upon the composition of these concretions. I shall divide what I have to say upon this subject, into eight paragraphs. In the first, I shall set forth in a few words, the history of the investigations and
chemical

chemical researches made upon the human urinary calculi; in the second, I shall occupy myself with their seat and physical properties; in the third, I shall enunciate the different materials, which constitute them, according to the last analysis made by Citizen Vauquelin, and myself; the fourth shall treat of their methodical classification: the object of the fifth shall be some considerations relative to their causes and formation; the sixth shall comprehend the examination of the solvents appropriated to these calculi; to the seventh, I shall refer the comparison to be established between the urinary concretions of man, and those of the animals; finally, I shall appropriate the eighth and last paragraph to the analysis of the arthritic concretions, in which there has long been admitted an intimate analogy with the calculi of the kidneys and bladder, though it has not as yet been sufficiently established by their chemical examination.

2. The ancients had no accurate notions of the nature of the urinary calculi, nor could they attach any interest to this kind of knowledge; for their notions respecting the composition of the different natural bodies, compared with each other, were absolutely nothing. From Galen to Paracelsus and Van Helmont, we find nothing but fictions or hazarded opinions, in the books of medicine. These two last medical chemists, without being better acquainted with the human urinary calculi, than those who had preceded

preceded them, began, however, to form some suspicions concerning their component principles, and to consider them as very particular matters. Paracelsus had invented the name of *duelck* for expressing this particular nature; and he thought that the calculi were composed of a fluid matter, and of a petrifying juice; though he well remarked, that there was an essential difference between the stones, properly so called, and the calculi of the bladder, which have been so inaccurately called *stones*. Van Helmont, in his celebrated treatise *De Lithiasi*, has introduced more of genius and imagination, than accurate results of experiments. We owe, however, to him, the ingenious notion of comparing the vesical calculus to tartar, and one of the first descriptions of the effects of distillation upon this concretion. He obtained from it, a fetid liquor; a yellow crystalline sublimate; an oil, similar to that of urine, and a friable coal, little saline. A singular approximation might be made between the results of Van Helmont, and the modern experiments.

3. The learned Hales has much insisted, in his animal statics, upon the aëriform product which the calculus of the bladder furnishes, particularly its quantity; he has explained its solidity by the presence of this fluid, which he considered as the cement of bodies. But this idea, which was adopted during more than 30 years, with enthusiasm, by the physiologists, has been

subverted by the discoveries respecting the elastic fluids, and their differences. A multitude of physicians have written upon the calculus, without better determining its nature. The principal authors of this class, since Hales, till in the year 1776, were Boerhaave, Slare, Denys, Detharding, Venette, F. Hoffman, Hartley, Wyth, Morand, Palucci, Lobb, Dessault, Lanne, Tenon, who with some true and well observed facts, upon the chemical phenomena, which the calculi of the human bladder present, have, however, consigned in the annals of science, nothing but errors and hypotheses, marked from time to time by some useful views, or by some ingenious ideas. Margraff himself, the last whom I shall mention in this list of men, who, notwithstanding their great talents, have made no advancement in the knowledge of the urinary calculi; Margraff, able chemist as he was, described in the year 1775, in the memoirs of Berlin, only the action of fire upon these concretions, and did not ascertain their nature. I shall not here speak of all those men of the faculty, who have written upon pretended lithontriptics, upon solvents of all kinds, and who have announced only erroneous results, without saying any thing respecting the composition of the calculi; an object so natural, and so necessary to be determined, before solvents could be proposed worthy of attention or confidence.

4. It is to Scheele, as I have already indicated in another place, that the first, and the most important discovery, respecting the human urinary calculi is to be attributed. Before him, it had been believed in a vague manner, that the matter of the calculi, was an earth analogous to that of the bones, of which also, no exact notion was possessed, as has been shown elsewhere. The illustrious Swedish chemist proved, in 1776, that these concretions were formed by a particular, almost insoluble acid, which the leys of caustic fixed alkalies dissolved well, and that they contained no lime. Bergman confirmed the discovery of Scheele, and announced, that he had obtained precisely the same result from his analysis. Though this is in fact one of the finest discoveries that have been made in chemistry, it is very remarkable, that Scheele pretended he had found exactly the same principle in all the human calculi, that he has asserted, that they were all solely composed of the same acid matter, and that he has not had occasion to observe such concretions of another nature; whereas there exist, as I shall make appear, at least four other materials in the different species of calculi of the human kidneys and bladder. We might be induced to think, that Scheele had never seen more than a single species of these concretions, or that he had seen only a small number, which presented no varieties to him in their composition.

5. Between the period of the discoveries of Scheele, and the inquiry in which Citizen Vauquelin and myself have been engaged since 1792, a considerable number of authors have published dissertations upon the urinary calculi, some of whom have confirmed the theory of the Swedish chemist, but these are the smallest number; the others have endeavoured to combat and invalidate it; some have added to it several facts, particularly upon the variation of their materials, and especially on the presence of the phosphate of lime in those concretions. Though there are still in works of this last-mentioned kind, incorrec^tnesses and even very serious errors; the authors have at least, no longer confined themselves to the distinguishing the urinary calculi, by their form, their colour, their surface, their size, their hardness, and only by their physical properties, as had been done before. It is to these three classes of inquiries, that we have to refer the memoirs and dissertations of Messrs. Dobson, Percival, Falconer, and Achard, upon the lithontriptic action of the carbonic acid, and of many others, upon the analysis of the stones of the bladder, especially of Messrs. Hartenkeil in 1785, Tychsen in 1786, Link in 1788, Titius in 1789, Walther in 1790, Brugnatelli in 1793, and Pearson in the first part of the philosophical transactions of 1798. I do not here mention a number of theses, or academic dissertations, which have appeared

appeared for twenty years past in the different universities of Germany, and in which we find nothing but repetitions or antiquated errors.

6. During this interval, being incessantly occupied with whatever appertained to animal chemistry, I had taken for one of the principal objects of my researches, the analysis of concretions of all kinds ; and I published at different times, in the *Annales de Chimie*, the results of my experiments. The labours of Mr. Pearson, which especially turns upon a critique on the discovery of Scheele, and by which he wished to prove that the matter, called *lithic acid*, in the French nomenclature, was not really acid, but a kind of animal oxide, induced Citizen Vauquelin and myself, to resume in the most extensive manner, the chemical examination of the urinary calculi, and to compare their differences ; for their aspect alone indicated to us, that there must exist, very considerable differences between them. We collected upwards of five hundred different specimens of these concretions, and their analysis led us to unexpected results. We saw, that instead of a single component matter of these calculi, which Scheele had admitted, there were four or five other different ones ; that sometimes each of these materials was insulated, and that frequently several were combined to the number of two, and even of three in a single calculus ; that we might, with reference to this mixture, or the
respective

respective disposition of these matters, classifying the urinary calculi in quite a different manner and with much more accuracy than had hitherto been done ; that the acid found by Scheele, actually existed, and ought not to be considered as mere oxide ; that the name of *lithic acid*, was not a proper one, but that that of *uric acid* ought to be substituted instead of it ; finally, that the lithontriptics must vary according to the nature of the calculi, and that they could not always be taken from the class of the leys of caustic alkalies, as the too limited analysis of Scheele indicated.

7. It results, in general, from the whole of these new facts, observed since the discovery of the Swedish chemist, upon the analysis of the human urinary calculi, which has at the same time been extended to that of the urinary calculi of several other animals, and of animal concretions of different parts of the body, that this part of chemical knowledge is at present much farther advanced than it was before ; that we have at present very extensive notions respecting the differences of composition existing in this class of matters ; that these notions, being introduced into medical science may throw the greatest light upon the formation of the different animal concretions, and upon several points of animal physiology ; that all the vague ideas, all the uncertain or hypothetical theories, hitherto presented upon the origin and the nature of the calculi of the kidneys, and of the bladder,

der, disappear and enter into the class of the fictions, with which this science has so long been over-loaded; that the doctrine of the lithontriptics, or solvents of calculi, being reduced to its just value, is as much perfected, or as far advanced as the art can hope; finally, that the means of analysing the animal concretions being now well determined, and sufficiently varied, for appreciating their real nature, the recourse ought no longer to be had to certain analogies which are often so fallacious in describing these concretions. All these new data shall be set forth in the course of this article,

SECTION II.

Of the Seat, and of the Physical Properties of the Urinary Calculi.

8. THE urinary calculi, being formed, as their name indicates, of one or of several matters contained in the urine, may occupy any of the places which this excrementitious liquid traverses. They are found in the pelvis of the kidneys, in the ureters, in the bladder, and in the urethra. Their concrete state has caused them to be called stones, and many authors have in fact, so far confounded them with these bodies, that they attempted to explain their formation by the same mechanism. Their first seat, or the place of their original formation, being the pelvis of the kidney, where the urine filtrates, it is by the separation or the crystallization of a substance

substance dissolved in this liquid, and which is too quickly deposited from it, that their concretion commences. They may, however, exist calculous concretions, formed originally in the ureters, the bladder, or the urethra; but these cases are in general more rare, and it is easy to see, that the calculi of these three last regions most frequently have for their origin, calculous nuclei, that have been formed in the kidneys.

9. The renal calculi, vary much in their ~~size~~ their form, their colour, their surface, their density, and their interior texture. They are most frequently small, concrete, roundish bodies smooth externally, brilliant and crystalline; of a reddish fawn, or wood colour, hard enough to take a polish, and which, on account of their smallness, readily move in the ureters and bladder, and are discharged by the canal of the urethra: they are then called *gravel*, which name is also given to the disease, in which they are voided. Sometimes the gravel are unequal granulated, rough at their surface, frequently even angular, prickly, pointed, and though small in size, they then occasion much pain and many accidents by lacerating the duct through which they pass. In other cases, and by a still more unfavourable disposition, the renal calculi, formed from the first of too large a size to be carried into the ureters along with the urine, remain in the pelvis, increase in volume, mould themselves upon its sides, extend themselves by branches and ramifications into
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the first divisions of this cavity, press and alter the texture of the kidney in such a manner, that this suppurates, wastes away, and leaves at last nothing more than a sort of cyst, filled with pus, and the solid concretion which has given rise to it. This case, indeed, presents itself but rarely; nevertheless, it is observed in dissections of subjects that have died in consequence of long protracted diseases of the urinary passages. Similar renal concretions of great bulk and hardness, have been found, even in persons who had complained of no sensation that could indicate their existence. The renal calculi, in these last cases, are generally of a brown, dark-red, or black colour, and covered with several external strata, proceeding from the pus or blood; some, however, are met with, which are yellow, reddish, crystalline, and of a homogeneous, calculous matter. It rarely happens, that the renal calculi, whatever may be their form or size, have a white or a grey colour. Amongst a great number, which I have had occasion to examine, I have not yet seen more than two of a mural nature, of a grey, blackish, and ash colour, and of a composition similar to what are called *mural bones of the bladder*, of which I shall speak hereafter: they are almost always uric acid.

10. The calculi of the ureters, proceed almost all from renal calculi, that have fallen from the kidneys into those ducts, and which having been too large to pass through them, have been detained in them. Frequently they become the

nucleus or centre of larger calculi, formed by the layers, which the urine incessantly deposits upon them; sometimes they dilate the ureter in an extraordinary manner, and cause it to assume the form of a bag, which retains the urine; these are, in general, rather rare concretions. There is another kind, which is still more rare; namely, the calculous incrustation that form themselves upon the sides of the ducts, when the urine is detained in them, as in the case that has just been mentioned. The internal membrane of an ureter, has been found incrustated with a deposition, which had mouldered itself upon this membrane; but this phenomenon is extremely rare; the incrustation is white, and formed in this case, of earthy phosphates. Sometimes the calculi of the ureters are perforated with a hole, which suffers the urine to pass through.

11. The calculi of the bladder are much more common than the preceding. They have been much more an object of attention, than the calculi of the kidneys, and of the ureters; they have been distinguished by all their physical properties; they have been classified according to their size, their form, their surface, their hardness, their strata, &c. Their origin, or their first formation, is three-fold; either they originate in the kidneys, and having arrived in the bladder by the ureters, they increase in volume by the addition of successive layers, deposited by the urine; these
calculi

calculi with a renal nucleus, are the most frequent of all; or they commence in the bladder itself, where they have their origin as well as their growth; or finally, they have for their base, or nucleus, a foreign body, introduced from without, and proceed only from some accident, by which this extraneous substance has been introduced into the bladder through the urethra. These, which are not very rare, are especially met with in women, in whom the form, the direction, and the small extent of the canal of the urethra, more easily admit of the introduction of extraneous substances. In hospitals, where lithotomy is practised, calculi are frequently met with, which have for their base, pins, particles of iron, of steel, of brass, of ivory, splinters of wood, pieces of cloth or linen. A rent, a fragment of a probe, a bullet, have also sometimes given rise to calculous depositions, which have surrounded them in the bladder.

12. Though there are a very great number of varieties of calculi of the bladder, according to their physical properties, these varieties may, however, be referred to some general heads, and these concretions may be methodically divided or distinguished by their mere aspect. I shall here consider them with relation to their form, their volume, their colour, their surface, their specific gravity, their smell, their interior texture, and their strata.

4. The form, though variable in the vesical calculi,

calculi, is, however, most frequently either spheroidal, or oval, or compressed upon two faces like almonds. Sometimes they are found polygonal or with facettes; this happens when there are several of them in the bladder; there are some even that are almost cubical, or cuboid. Their extremities are frequently unequally pointed or obtuse. They are rarely found of a cylindroid form, and still more rarely in cylinders, terminated by kinds of heads, supported upon a contracted part. There are some also in the form of spheroids, with two ends, and contracted or strangulated at the middle: some have points bent backwards.

B. The volume is the circumstance, in which the calculi of the bladder vary the most; some are only of the size of small beans, whilst some are met with, that entirely fill this organ. Those of the middling size, and which are the most common, vary in bulk from that of a pigeon's to that of a hen's egg.

C. The colour deserves to be carefully distinguished in these concretions, because it indicates their nature. We must not confound with the proper colour of the calculi, the red or brown spots or coverings, which frequently proceed from them. There are three kinds of colour in these calculi; the yellow-fawn or wood-colour, which varies in its cast, from a kind of pale yellow, to a reddish or brown-red colour, analogous to that of some kinds of marble: this is the colour of the calculi formed of uric acid;

the more or less pure white, or greyish-white, which always announces the earthy phosphates; and the dark-grey or blackish, frequently with a pearl-grey cast, indicative of the oxalate of lime, which constitutes the mural calculi. There are also some vesical calculi, shaded or spotted with brown or dark-grey, upon a wood-yellow or white-ground. The brown or dark-grey spots, which generally project in relief, are the extremities of tubercles of oxalate of lime or mural calculi, placed in the centre, and as it were, cased uric acid, when the ground is of a wood-yellow colour, or in phosphates when the ground is white. These various species of calculi, generally present the brown points only at their middle, or at one of their extremities. In the latter case, the mural nucleus is eccentric. What I have here enunciated, respecting the colour of these concretions, is the result of my observations, upon more than six hundred calculi, thus reduced to a certain number of general classes. Authors have described green, olive-coloured, blueish, rose-coloured, yellow calculi; but these are only signs of extraneous matters, or shades of some of the colours that have been indicated.

D. The exterior, or the surface of the vesical calculi, presents a great interest to the observer, both for the appreciation of their effects in the bladder, and for understanding their nature. Their surface is sometimes smooth and polished,

polished, and then it resembles marble; and then it is at the same time of a dull wood colour. In others, it is uniform without being polished; sometimes it is unequal, gravelly, full of small rough or smooth tubercles, always with the same wood-colour. The same kind of calculi, sometimes also present only one part of their surface smooth, and the rest rugged. Some are also seen, upon which there are kinds of appendages or depositions of the same nature, in projecting tubercles or gravel. Frequently an external stratum, thin and interrupted in some points, presents the appearance of a kind of bark or crust.

The white calculi are sometimes even and smooth, sometimes semi-transparent, and charged with brilliant crystals, and by this character, they indicate the ammoniaco-magnesian phosphate; sometimes they are dull, of a fine gravelly grain or roughness to the touch, or perforated, carious, and as it were spongy, and then they are formed of phosphate of lime.

The brown or dark-grey calculi, are called *mural stones*, because their projecting, tuberculated surface, frequently polished and brilliant at the extremity of each tubercle, resembles the agglomerated tubercles of mulberries. Some of these are found, which are fretted with elongated tubercles, projecting into sharp points, like the prickles with which some shell-fish are armed. These are the most terrible kind of calculi, on account of the excruciating pains which

they excite, and the dangerous laceration which they produce upon the sides of the bladder.

The specific gravity of the urinary calculi of the bladder has not yet been indicated: I weighed about 500 of them, and of very different species, with much care: I have found the weight of the lightest of them, was to distilled water, as 1213 to 1000; and the heaviest 1976: 1000. This density, is not so great as that of water, but inferior to that of the stones properly so called, shows that the denomination was improperly applied.

But it, however, announces, that the urinary calculi approach near enough to them, not to be led to the mistake; they are frequently smooth enough to receive a fine polish; they are very brittle.

To indicate the smell among the varieties of urinary calculi of the bladder, because in fact, this smell varies in them in three ways; sometimes sensibly urinous and ammoniacal, either when they are rubbed, or when they are sawed; sometimes it is simply earthy, and as it were, like chalk; as it is frequently observed in the white stones, sometimes it is perfectly similar to that of bone or ivory, when sawed or rasped, and sometimes it is like that of the sperm: the latter smell is most frequently found in the mural calculi; it may therefore serve to characterize them.

The interior texture of the vesical calculi, presents such variations in these concretions, that

that we may be certain that we have only a very inaccurate, and very imperfect notion of their nature, when we do not saw them, and do not make the section pass through their centre. Their exterior surface, indeed, never accurately announces what they are internally, especially when they are of a size exceeding that of a pigeon's egg. When the vesical calculi are broken, which is easily done, either by striking them with a hammer, or by letting them fall from a height of one or more metres, they generally separate into two or three layers, more or less thick, even, and almost polished at the fractured surfaces, or only a little rugged, which shew that they have been formed by successive depositions, at different periods. The very fine striated fracture, and the wood-yellow, or homogeneous reddish colour of their interior, belong especially to those that are formed of uric acid. This texture may be still better seen, by sawing them; their centre is generally occupied by a nuclens of the same nature, which is easily detached, and their exposed internal surface, which sometimes presents strata of tinges a little varied, receives a fine polish, similar to that of marble or serpentine stones.

When the strata exposed by the section, are white, semi-transparent, or when their fracture is lamellated and spathic, they indicate the ammoniaco-magnesian phosphate; when very brittle, and breaking into small opaque and friable
layer

layers by the motion of the saw, they indicate the phosphate of lime; when very hard, difficult to be saved, resisting the instrument, exhibiting a smooth surface of a dark-grey colour in their section, and exhaling a smell of ivory; they are formed of oxalate of lime.

Frequently exterior white layers of earthy phosphates, present at their centre a nucleus of yellow matter, consisting of uric acid, or a centre of a brown-grey colour of mural matter. Sometimes this last-mentioned nucleus is covered with yellow striated layers of uric acid. In these two last kinds of calculi of two or three different matters, the mural centre appears, as it were, radiated in its section. When the nucleus or centre is uric acid, covered with white layers of phosphates, it is, on the contrary, of a circular or oval form, but with an equal curvature, and without a radiated structure. It is rare to see the three layers, the external of phosphates, the middle of uric acid, and the central of calcareous or mural oxalate: and still more rarely these three bodies, distinct in their colour, their texture, and their form, envelope each other several times alternately, and in an order different from that which has been indicated.

It must be evident, from this description of the varieties of the layers, and texture of the vesical calculi, that the comparison of their aspect may serve to enable us to recognize them, and to divide them into a certain number of distinct species.

13. It is rare for the urethra to contain calculi proper to it; this case however, is not without some examples. Calculi have been seen formed in the fossa navicularis, in the vicinity of the bulb of the urethra; it has been seen, that foreign bodies that had remained in this canal, and most frequently probes that had been left in it for some days without being moved, became covered with white calculous incrustations. With women, who have long worn a pessary, it is pretty common to find brilliant crystals of ammoniaco-magnesian phosphate, formed upon the part of this instrument next to the canal of the urethra, and continually irrigated by the urine. The urine detained between the glans and the prepuce, has also been several times known to give rise to white concretions, which an unaccountable carelessness in the persons afflicted with them has suffered to grow to an extraordinary size. In the anatomical collection of the school of medicine in Paris, two concretions of this kind are kept, which were observed, and given to us by Citizen Sabbatier, one of its professors. In all cases, the calculi of the urethra, formed like incrustations upon foreign bodies introduced into this canal, or produced by the long retention of the urine, are constantly composed of earthy phosphates, which, as has been seen in the chemical history of this liquid, easily separate from it. There are also urethral calculi, that proceed from the bladder, and which

are

sis, by discovering that the calculi were formed by a concrete insoluble acid, peculiar to this class of bodies; nevertheless this able chemist was mistaken in believing that this acid matter universally constituted all calculi. It must have appeared that, after him it had been found that the phosphate of lime constituted an essential part in the composition of several of them; that it had even been attempted to re-examine the acid nature of the most frequent calculous matter, and that it was endeavoured to consider it as in the simple state of animal oxide, characterized by specific properties no less singular than distinct. It is probable, that without this last-mentioned opinion of Mr. Pearson, which likewise coincided with the results of Messrs. Linck, Hartenkiel, Walther, &c. relative to the simultaneous existence of the phosphate of lime, and of the uric acid in calculi, Citizen Vauquelin and myself should not have been led to the discoveries which we have made upon the much more numerous materials of the urinary calculi.

15. The researches in which I had formerly been engaged, from 1786 to 1793, upon concretions, and which I wished to pursue; the necessity of ascertaining, with much accuracy, the validity of the ideas which Mr. Pearson had set forth, and of knowing whether he had good reasons for disputing our denomination of acid given to the vesical calculus; the certainty, already produced by my former
 4 inquiries;

inquiries, that this calculus was formed of something more than the acid discovered by Scheele, and the suspicion that this matter combined with the calculous acid might itself be varied or multiplied; finally, the hope of determining with precision what was to be expected from lithontriptics: such were the various motives which induced Citizen Vauquelin and myself to employ our greatest attention in the analysis of the human urinary calculi; and after having collected several hundreds of them, through the assiduity and kindness of several physicians, especially Citizens Sabbatier, Lassus, Pelletan, Jussieu, Boyer, Deschamps, at Paris; of Citizens Noël, of Rheims; Petits, of Lyons; Pamard of Avignon; Maussion, of Orleans; and especially of Citizen Giobert, of Turin, who possesses a collection of several thousands, of which he generously offered us a share, we employed the whole summer of the year 6, and that of the year 7, in pursuing without intermission the examination and analysis of these concretions.

16. As the result of our numerous experiments, so frequently repeated and multiplied as to leave no room either for doubt or error, instead of two substances which were all that had been ascertained to exist in the human urinary calculi, previous to our labours, we found seven very distant substances; namely, the uric acid; the urate of ammonia; the phosphate of lime; the ammoniaco-magnesian phosphate; the

the oxalate of lime ; silex, and an animal *matter* frequently variable in the different *species* of calculi.

We gave, in a first and very circumstantial *Memoir* read to the Institution in Vendemiaire of the year 7, all the details of the experiments that have led to the discovery of these seven substances. If we except the uric acid and the phosphate of lime, we could not have, according to more early analyses, any notion, or even any suspicion of the five other substances which presented themselves to our researches as materials of the urinary calculi. Without entering into the same details here, I shall explain the chemical characters of each of these materials, in order to show to chemists and physicians the means of distinguishing them hereafter, and also to direct my proceedings in the distinction of the species and varieties of these concretions.

A. *Of the Uric Acid.*

17. THE uric acid discovered by Scheele successively denominated *benzoardic acid* and *lithic acid*, previous to the appellation which I here assign to it, because the first of these names would give it a latitude which does not belong to it, and because the second associates it with stoney substances from which it differs widely is very truly a particular acid, and is not to be ranked in the class of the oxides, as

Mr

Mr. Pearson had believed. The following are the properties which Scheele had pointed out in it, and by which he had characterized it. The uric acid is insipid, inodorous, hard, crystallized, almost insoluble in cold water, soluble in several thousand times its weight of boiling water, from which it separates by cooling, in small yellowish crystals; it easily dissolves in fixed alkaline leys: it is precipitated from them in a white powder by all the other acids, even the carbonic; it is almost unattackable by the sulphuric and muriatic acids, soluble in the concentrated nitric acid, to which it gives a red colour; it yields in distillation a small quantity of uric acid, which is sublimed without decomposition, very little oil and water, crystallized carbonate of ammonia, and carbonic acid gas: it leaves a very black coal without alkali and without lime.

18. I shall add to these characters indicated by Scheele, and according to our own particular researches, the other properties, to the discovery of which we have been led by a long continued investigation of this acid. When it is triturated with concentrated leys of pot-ash or soda forms at first a kind of saponaceous matter, thick, clammy, very soluble in water when it contains an excess of alkali, little so when this is neutral. The saturated urates of pot-ash and of soda are little sapid, little soluble, crystallizable. When their solution diluted with water is precipitated by the muriatic acid, the

the uric acid is obtained in small crystals, aculeated, brilliant, very voluminous, little coloured, and only of a slight yellowish tinge, in comparison with the wood colour which characterises this acid when alone. Ammonia does not dissolve the uric acid, or dissolves it but very little and the urate of ammonia is scarcely soluble. Lime water likewise dissolves it only in very small quantity. The alkaline carbonates have no action upon it. The nitric acid, whilst it dissolves it and gives it a red colour, changes its nature and converts a portion of it into oxalic acid. The colouring of the nitric solution, mentioned by Mr. Pearson as a decisive character of what he believed to be an oxide of a particular kind, it not owing to the uric acid, but to an animal matter which accompanies it, and which seems to be a small portion of urée. I am warranted in adopting this opinion by the acid of nitre becoming coloured in the same manner by the extract of urine, and by the other experiment which follows.

19. The oxygenated muriatic acid soon alters the nature of the uric acid, either when a calculus is suspended in the acid liquid, or still more easily, when oxygenated muriatic acid gas is made to pass into water, at the bottom of which uric acid in powder is placed. Its colour becomes paler, its surface swells, it softens and becomes as it were gelatinous. This part disappears and soon dissolves, rendering the liquor milky. All the calculous acid undergoes the

the same solution by successive strata; there only remains about a sixtieth part of white flocky animal matter. By a slow and continued effervescence, small bubbles of carbonic acid gas are disengaged. The liquor when well dissolved, gives by evaporation muriate of ammonia, acidulous oxalate of ammonia, both crystallized, free muriatic acid and malic acid. Thus the oxygenated muriatic acid decomposes the uric acid, converts it into ammonia and into carbonic, oxalic, and malic acids. The first of these acids is disengaged; the second combines with the ammonia into an acidulous salt, at the expence of the muriatic acid, part of which remains free in the liquor. As to the malic acid, it remains in the liquor, when it yields no more crystals, and may be obtained by evaporation to dryness. The white insoluble flocks, which form about a sixtieth or seventieth part of the uric calculus, are the same animal matter with that which gives the red colour to the solution of this species of calculus in nitric acid; and it is from a portion of this matter that the red colour and the cubic form of the crystals of muriate of ammonia, furnished by the evaporation of the liquor, proceed. It is to be remarked that the first action of the oxygenated muriatic acid upon the uric acid is to convert it into ammonia and into malic acid, if but little of the re-agent is employed; that a larger dose causes this to pass into the state of oxalic acid; and that if much

much oxygenated muriatic acid be employed, both these acids are completely decomposed, and reduced to the state of water and carbonic acid.

20. Another character belonging to the uric acid, is the manner in which it is affected by fire; it not only yields carbonate of ammonia by distillation with a naked fire; it is in part sublimed, and furnishes carbonic acid gas, on which Hales, mistaking it for air, insisted so much; but it is also very remarkable for the small quantity of oil which is formed by the action of the caloric; by the Prussic acid, which is developed, and which is found amongst its products, both gaseous and liquid; by the coal, not saline, though considerably abundant, which it leaves as its residue; by the small quantity of water which is separated from it in this analysis by fire; by the peculiar fetid smell, analogous to that of burnt horn or bones, which is found in all the products of this kind of concretions; by the mixture of the smell of bitter almonds with this odour, which is so striking and so remarkable.

All these facts shew that the uric acid is an animal compound of a very particular kind, formed of azote, of carbon, of hydrogen, and of oxygen, susceptible of a considerable number of different alterations by chemical re-agents, especially of being converted into ammonia and into four different acids, the malic, the oxalic, the Prussic, and the carbonic, according to the more

less advanced state of its decomposition. This acid, which is entirely peculiar to animal substances, of which it is one of the secretions, when it cannot be voided with the urine, which naturally holds it in solution, either because it is too abundant, or because there is some foreign substance upon which it may be deposited, carries with it, in its calculous concretion, a portion of an animal colouring matter, which gives it the wood yellow or light red tinge, and which appears to be of the same nature as the urée. It even appears that the uric acid proceeds from this last-mentioned matter, though I have not yet been able to determine by what change the one of these substances passes into the state of the other.

B. *Of the Urate of Ammonia.*

21. **THERE** is reason to believe that the urate of ammonia, which we have found pretty frequently in the urinary calculi, was confounded previous to our inquiry with the pure uric acid. Scheele met with it without knowing it, for he has remarked, that the stones of the bladder frequently diffused ammonia during their solution in the leys of caustic fixed alkalies. This is in fact the unequivocal chemical character which distinguishes it from the pure uric acid: it dissolves like the latter in the leys of pot-ash or of soda, but its solution is accompanied with an abundant disengagement of ammonia

ammonia, whilst that of the pure uric acid takes place without any smell of ammonia. Its purity is ascertained by its entire and complete solution in these leys. If there remains any thing undissolved, this matter is neither urate of ammonia nor uric acid : it consequently belongs to one or other of those which follow.

22. The urate of ammonia is almost always distinguishable by its thin and united strata which are not constantly smooth ; by the small size of the calculi which it generally forms ; by the colour of coffee with milk which it commonly presents. Though it is sometimes alone, it is most frequently mixed with earthy phosphates, interposed between its layers, in the urinary calculi of which it forms a part. It is hardly more soluble in cold and hot water than the uric acid. The acids act on it in the same manner as on the latter, except in their previous saturation with its ammonia, which requires a greater quantity of acid to change its nature. The urate of ammonia is most frequently mixed with ammoniaco-magnesian phosphate, as it appears to exist only after the formation of a quantity of ammonia, sufficient for first saturating the native phosphate of magnesia of the urine, and afterwards the uric acid, which is naturally free in it. Its characters are so simple, and, at the same time, so well marked, that it will be impossible hereafter to mistake it.

C. Of the Phosphate of Lime.

23. HITHERTO, the presence of the phosphate of lime in the urinary calculi had been indicated only in a vague manner; all that was not uric acid passed for this calcareous salt. Being obliged to distinguish this compound from five other substances, which may be found with it in these concretions, we endeavoured to find in its apparent or physical properties, and in its chemical properties, characters adapted for determining its nature without doubt, ambiguity, and error. The following is what a long habit of describing and examining the calculi has furnished us respecting these subjects.

The calculous phosphate of lime is in thin layers, friable, or of little consistency, breaking into splinters or scales under the saw, of a dirty white, or somewhat greyish colour, without lamellated or spathose crystalline form, dull, and opaque, without smell and without taste. Sometimes, instead of numerous layers that have little adhesion with each other, it presents incoherent grains, truly friable, feebly aggregated together by a rapid deposition, like the molecules of incrustations and osteocollæ: many pores and cavities are seen in it, as in a spongy texture; it never singly composes a human urinary calculus.

24. However white and pure the phosphate of lime in the vesical concretions may appear to the

the eye, it is always intimately united with a animal gelatinous matter, as in the bones; and it is on this account that it becomes black and coaly when it is strongly heated: it diffuses a smell of burned horn or bones; it yields water, oil, and carbonate of ammonia, in the retort and leaves a coaly residuum. Calcined to whiteness, it does not yield lime, but only phosphate of lime, deprived of its water of crystallization. It is perfectly insoluble in cold water: when it is heated with boiling water, a portion of gelatine dissolves in this liquid, and diffuses a very distinguishable faint animal smell. All the acids, even when weakened, except the boracic and the carbonic, dissolve this salt, and convert it into an acidulous phosphate: it is especially by the nitric and muriatic acids that its solution is quickly and easily effected without effervescence. Fragments, or entire layers, of this calculous phosphate, suspended in either of these acids, diluted with water to such a degree that they may be drank, leave transparent and cellular flakes of animal matter, in proportion as the earthy salt dissolves. Its acid solution is precipitated by the pure alkalis and ammonia, without decomposition; the precipitate, collected and dried, is always phosphate of lime. When this salt is treated with the sulphuric acid, a little concentrated, it forms a thick magma of sulphate and of acid phosphate of lime: the alkalis and alkaline carbonates have no action upon it. We have never found

in the white calculi, or in the white strata of urinary calculi, the acid phosphate of lime, which Citizen Brugnatelli says, he has met with in them.

D. Ammoniac-magnesian Phosphate:

25. It has already been said, that urine, kept till it becomes ammoniacal, yields transparent and white prismatic crystals of ammoniac-magnesian phosphate. It appears, that it is by a similar phenomenon that this salt, which is frequently found on the outside or in the exterior strata of urinary calculi, is formed in the bladder. The ammoniac-magnesian phosphate of the calculi is easily distinguished by its physical properties: it is in lammellated, spathose, semi-transparent, hard, and coherent strata; it can be sawed very well, and does not break like the phosphate of lime; under the saw it gives a fine powder, smooth to the touch, of a brilliant whiteness; whilst that of the calcareous phosphate is coarse, and of a dirty dull white. It has a sweetish, faint taste, and dissolves a little in the mouth: sometimes it is in the form of rhomboidal brilliant crystals, or of square glittering laminæ, disseminated in the cavities of other calculous matters. When it has once been well examined, and especially when it has been compared with phosphate of lime, placed by the side of it, it is no longer possible to confound or mistake it, so decided
and

320 AMMONIACO-MAGNESIAN PHOSPHATE.

and striking are its sensible properties or exterior characters.

26. Its chemical properties are less distinctly marked, and less calculated to enable us to know it without ambiguity. Though it contains, like the phosphate of lime, a small quantity of gelatinous animal matter between its laminae, and becomes black when it is heated, it evidently shows less of it than the former, and is more purely saline. It dissolves in water, sparingly indeed, but sufficiently so for its solution to crystallize by spontaneous evaporation; it dissolves more easily and more speedily in the acids than the phosphate of lime; weak sulphuric acid dissolves it completely, and forms ammoniaco-magnesian sulphate; its fragments, suspended in the nitric and muriatic acids much diluted, disappear in them more rapidly than those of the phosphate of lime, and leave lighter and less abundant membranous flakes in it. Ammonia precipitates from it only light magnesian flakes, or even not them, if the solvent acid is in great excess; whereas, it renders the solution of calcareous phosphate strongly turbid. The leys of caustic fixed alkalies disengage the ammonia from it, without retaining it in the solution; they take from it the phosphoric acid, and leave the magnesia precipitated and uncombined. It was this last-mentioned character, of disengaging at the same time ammonia without dissolving it, and of affording magnesia as a residue, while the properties of an alkaline
phos-

phosphate were shewn in the solution, which enabled us to recognise this salt as ammoniaco-magnesian phosphate.

E. Of the Oxalate of Lime.

27. WERE it required here only to describe the means of determining the oxalate of lime, which forms part of the calculi, and of distinguishing it from all the other materials of which they are constituted, it would be almost sufficient to call to mind the name of *mural stone*, which the concretions formed of it bear, a name which has long been adopted on account of their figure and texture. In fact, we have found this earthy insoluble salt only in the calculi so denominated; and this species has constantly presented to us oxalate of lime, united to an animal colouring matter, so that the singular form, from which they take their name, appears to be essentially dependent upon the nature of their composition. I may therefore say, that the calculous oxalate of lime is crystallized or deposited in unequal layers, as if festooned, presenting on the outside tubercles more or less prominent, sometimes pointed, sometimes rounded, rough or polished, analogous to the tubercles of mulberries, of a dark grey or brown colour without, of a dirty grey, frequently with white veins within, of a dense, fine texture, susceptible of taking the polish of ivory, resembling in its fracture scales

or conchoidal fragments, and exhaling, when sawed, the faint, animal, and spermatic smell, which is omitted by bones and ivory. This is the heaviest of the calculous matter.

28. The chemical properties of the oxalate of lime are as well marked, and as easy to be distinguished as its physical characters. It is the only one of the materials of the calculi which gives, by calcination, a residuum of lime forming about a third of its weight. The acids dissolve it with great difficulty, and its nitric solution suffers this salt to be precipitated, without alteration, by the addition of the alkalies. These, however caustic they may be, have no action upon this calculous matter; but the solutions of alkaline carbonates of potash and soda decompose it completely. For this purpose, nothing more is required than to heat the calculous oxalate of lime in powder for some minutes in these solutions: the product is pulverulent carbonate of lime, easily distinguishable by its solubility with effervescence in the acetic acid; and the supernatant liquors contain an alkaline oxalate, which is precipitated by the acetite of lead or of barytes, and the precipitate of which is decomposed by the sulphuric acid: this forming an insoluble sulphate of barytes or of lead, leaves the oxalic acid, which may be obtained by evaporating the supernatant liquor from either of these salts. There remains no uncertainty, according to this mode of analysis, since there is no matter of the urinary

rary calculi, which yields similar results with this kind of reagent, and because the oxalate of lime is the only compound which possesses the chemical properties, and follows the laws of decomposition here indicated.

29. One of the characters of the calculous oxalate of lime, consists in the abundance and the nature of the animal matter which constantly accompanies this salt, when deposited in the bladder. It is this matter which gives it the brown, chestnut, dark-red, blackish-grey, and foot colours; for the mural calculi are susceptible of these different tinges. From it proceeds also the fine dense, and close texture, which this concretion possesses. It is obtained sufficiently uncombined, when a fragment of this calculus is dissolved in weakened nitric acid, by keeping it suspended in it by a thread; in proportion as the oxalate of lime dissolves in the acid, the animal matter, preserving the primitive form and colour of the fragment, and swelling, becomes soft, spongy, and remains much more dense than the light membranous flakes left by the earthy phosphates, when treated in the same manner. Hence we see that this animal substance is more dense, and more abundant than that which exists in the other calculous matters. It is evident, that the singular hardness of this kind of calculus, proceeds from the intimate approximation of the particles, produced by the union of the oxalate of lime with this animal compound; as we see lime incorporated with

the white of egg, assume a very solid state in chemical lutings. As to the nature of this animal matter, though we have not yet analyzed it in particular, it appears to be a mixture of albuminous matter and urée: the first is indicated by its concretion and sparing solubility in acids, the second by its colour.

F. *Of the Silex.*

30. THOUGH accustomed, for more than ten years, to find this earth in many compounds, in which it had not formerly been suspected, we were very much astonished to meet with it in the human urinary calculi. It is true, that amongst six hundred which we analyzed at this time, with sufficient accuracy to determine well their nature and composition, only two calculi presented themselves, in which we ascertained the existence of this earth. But this fact, which indicates at least the possibility of its existence in the urinary calculi, and the necessity of reckoning it amongst the number of the calculous materials, is not the less singular, and in some degree extraordinary. It was in these two calculi, of mixed composition in their centre, which presented the foliated texture, and the festoon-formed strata of a mural stone, that we discovered this new component part of the urinary concretions. Calcined to redness in a silver crucible, these calculi lost
only

only a third of their weight, without yielding free lime; the acids in which this residue was boiled, took up nothing from it; heated and fused with four times its weight of alkali, and afterwards treated by the muriatic acid, this residue concremented into a jelly by evaporation, and presented all the characters of filex.

31. The examination of all the chemical phenomena, which these siliceous calculi presented by the action of fire, of water, of acids, and of alkalies, proved to us that the filex, which formed an essential part of them, was mixed in them with phosphate of lime, and an animal matter, analogous to that which generally accompanies the calcareous oxalate. They are likewise hard, and difficult to be sawed or pulverised; their powder, which is rough to the touch, scratches those metallic surfaces upon which it is rubbed. They diffuse an animal odour when they are burned: they give scarcely any thing to boiling water. The acids take from them only a small quantity of calcareous phosphate, which however, is not separated without difficulty from the filex, to which it intimately adheres. Neither the pure alkalies, nor the alkaline carbonates, have any action upon calculi of this kind; they dissolve hardly any part of them, and only separate from them a very small quantity of animal matter. Their true distinctive character consists in their fusibility with the caustic fixed alkalies, and in the vitrification which they experience

perience with this reagent. The absence of the properties that belong to the other species of calculous matters hitherto treated of, added to the character just indicated, can leave no doubt respecting their peculiar nature.

G. *Of the Animal Matter.*

32. It has already been seen, that each of the six substances which form the different materials of the human calculi, is constantly united with an animal matter. The proof of the constant existence of the latter is drawn, both from the property of being reduced to coal, which belongs to all calculi; from the products which they furnish in distillation; from the fetid smell which they emit when they are burned; from the faint odour which they exhale during their decoction in water; and finally, from the light, transparent or spongy and coloured, or membranous and cellular flakes, which the fragments of calculi leave, when they are dissolved by suspending them in diluted acids. Excepting the uric acid, and the ammoniacal urate, which, as animal compounds, are reduced to coal, and changed into volatile products by the action of the fire, the four other calculous materials, the two phosphates, the oxalate of lime and the silix, would present neither of these characters, were they not united with an animal substance, more complicated than

than themselves in its composition. Thus none of these materials is perfectly uncombined in the urinary calculi; none is exempt from association or combination with an animal matter, which several authors have already admitted in them, and which they have frequently considered with justice, as the primitive rudiment of these concretions; as in the bones, the gelatinous substance, forms the first base of a kind of organic texture, in the areolae of which, the calcareous phosphate is deposited.

33. But what is remarkable in this association of animal substance, with all the different constituent materials of the urinary calculi, is, that each of them seems to be united with a different animal matter. Sometimes albuminous, sometimes gelatinous, sometimes a mixture of both, sometimes, and even frequently, accompanied with the matter peculiar to the urine, which I have called *urée*; this animal rudiment seems to give a constant character to each species of calculous compound. Thus the uric acid, and the ammoniacal urate, contain a sort of albumen charged with *urée*: the earthy phosphates contain albumen and gelatine in a membranous or lamellated and cellular form: whilst the oxalate of lime conceals among its dense and festoon-formed strata, a more compact spongy texture, better supplied with a coloured and more condensed albumen, whilst the *silice*, enveloped in the calculi, of a substance considerably analogous to this last, resembles

resembles also the mural calculi, both in the structure which it affects, and in the density which it acquires in these kinds of concretions.

The animal matter which exists in all the calculi, is therefore not the same in their different species; it varies according to the different materials which it accompanies, and it might be said, that there exists a sort of relation between the nature of the calculous concretion, and that of the gluten, which connects its particles. It may nevertheless, be regarded in general, as a gluey or glutinous mucilage, which connects, unites, and holds together, the acid or saline particles of which, the concrete part of the urinary calculi is principally formed.

SECTION IV.

Of the Classification of the Human Urinary Calculi.

34. THE ancient modes of classifying the calculi according to their form, their volume, their surface, their colour, &c. can no longer be sufficient at present, when, according to our last experiments, an accurate knowledge of their intimate nature has been obtained. It is very evident, that it is according to the com-

position of these concrete bodies, that they ought now to be classified, and arranged with respect to each other. Besides, the only object of this distinction, is merely the methodical arrangement of the calculi, and their simple differences of aspect, and of physical properties. Though these always accord with the chemical characters, and though the mere aspect may serve to point out their nature, there is besides the great advantage of adding to this first knowledge, that of the solvents appropriated to each calculous matter, or to the union of these matters, which must render a classification founded upon the well determined composition of these concretions, more valuable and more useful.

35. When we call to mind the seven different materials which constitute the urinary calculi, and the constancy with which each of them is accompanied with an animal substance, we perceive at once, that there is not one of these calculi which is composed of a single matter. But as the animal substance exists in all, and even almost always forms their gluten, as besides, it has not a sufficient influence upon their difference, to cause them to vary sensibly in their properties, I shall pay no regard to its presence, in classifying these concretions. From a comparison of all the facts, which the accurate analysis of more than six hundred calculi, has hitherto presented to us, I find, that they may be distinguished into three classes; the first,

first, of calculi formed of a single substance, besides the animal matter which connects its particles; the second, always without taking this matter into consideration, composed of two calculous substances; and the third containing more than two different substances, frequently even four. These three classes comprehend together, twelve species which we have already found; they may, however, comprehend a much larger number, for it is evident that the six calculous materials, considered one by one, or in their union, two and two, three and three, four and four, would give many more species, were we to consider all these possible combinations, as actually existing; but we have here to treat only of what has been hitherto found by experiment, not of what may be found hereafter.

36. Of the twelve species of calculi, which our analyses have made us acquainted with, only three belong to the first class, namely, of those formed of a single calculous matter: these are,

First species, those of uric acid;

Second, those of urate of ammonia;

Third, those of oxalate of lime.

Hitherto, neither the calcareous phosphate, the ammoniaco-magnesian phosphate, nor the filix, have been found uncombined.

There are seven species in the second genus, that is to say, amongst the calculi formed of two calculous materials, besides the animal

matter, which renders their compounds ternary, as it renders the preceding binary. I dispose these seven species in the following manner, according to our analyses.

Fourth species: uric acid and earthy phosphates, in very distinct strata.

Fifth species: uric acid and earthy phosphates, intimately mixed.

Sixth species: urate of ammonia and phosphates, in distinct strata.

Seventh species: the two preceding materials, intimately mixed.

Eighth species: earthy phosphates, mixed either intimately, or in fine strata.

Ninth species: oxalate of lime and uric acid, in distinct strata.

Tenth species: oxalate of lime and earthy phosphates, in distinct strata.

Finally, the two last species form the third class, or the calculi, containing three or four calculous substances: viz.

Eleventh species: uric acid, or urate of ammonia, earthy phosphates, and oxalate of lime.

Twelfth species: uric acid, ammoniacal urate, earthy phosphates, and filix.

I shall add to this enumeration, some lines respecting each species in particular.

37. The calculi of uric acid, or of the first species, are the most frequent of all, very distinguishable by their wood, or fawn, or reddish colour; by their brittle, radiated, dense, homo-

geneous, and fine texture, by their complete solubility without smell, in the leys of caustic fixed alkalies. They vary in size from that of a small pea, to the bulk of a duck's egg, or even larger than that : their rounded, spheroidal, compressed, ovoid, elongated form; in their surface, which is sometimes smooth like polished marble, sometimes a little rough or tuberculous, hardly ever pointed or spinous; in their colour, which is rosy, yellowish, fawn, light-red, light-brown, veined, uniform, spotted with different colours, never white, grey, or black; in the number of their strata, which are sometimes extremely thin, sometimes very thick; they frequently separate in a part of their thickness, into layers, with a polished surface. Their specific weight, is from 1,276, to 1,786; most frequently it exceeds 1,500. The renal calculi are generally of this species. Amongst 600 calculi, I have found more than 150 of pure uric acid.

38. The calculi of urate of ammonia, or of the second species, well characterized by their solubility in the leys of fixed alkalies, like the preceding, but with an abundant disengagement of ammonia, are generally small, of a pale colour, like that of coffee with milk, or of a grey, inclining to this cast, formed of fine strata, which are easily detached from one another, and which are smooth at the surfaces which touch each other, almost always containing a nucleus, from which the covering may easily be separated. Their most common form
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is spheroidal, elongated, compressed, sometimes amygdaloid; their surface is generally smooth, never tuberculous, sometimes brilliant and crystalline; their specific weight is from 1,225, to 1,720: water alone dissolves them particularly when it is hot, and when they are in the state of fine powder. The acids, especially the muriatic, deprive them of the ammonia, and leave the uric acid, which is afterwards soluble in pot-ash, without effervescence; they are sometimes found covered with pure uric acid; the exterior layer of this is generally of little thickness, and the greater portion of the calculus is urate of ammonia. Among the 600 calculi that were examined, the proportionate number of the individuals of this species, was one of the smallest.

39. The calculi of the oxalate of lime, or the third species are extremely distinguishable and well characterized, as I have said above, by their rugged, tuberculated, fretted surface, armed with points or prickles, on which account they have received the name of *mural*, or *mossiform* stones; by their external brown soot colour; by their hardness, their dense texture, the grey tinge, the ivory polish of their interior, and by the smell of sperm which they emit when they are sawed. They differ more especially from all the other species, by the lime which they leave after calcination, by their difficult solubility in the acids, their perfect insolubility in the alkalies, and the impossibility of effecting

effecting their decomposition, unless aid of the leys of alkaline carbonates.

Though placed in the class of cal single solid matter, they contain, as I elsewhere, an abundant animal which retains their form after the lime, which renders them solid, is removed. They weigh between 1,428, and 1,970 grains; their bulk varies much between that of a small calculus, and the size of a turkey's egg, even a little more. However the large and the small ones, are the most common varieties of this species: their form is generally spherical, or spheroidal; their surface is always unequal, varies singularly in the points with which it is armed to the sharp and polished tubercles, with which it is studded in some specimens. They frequently constitute the nucleus, or centre of other calculi, but in that case being covered with a calculeous matter, they belong to another class. Their proportion, in a number of the stones that were analyzed, was found to be one fourth or a fifth.

40. The calculi of the fourth species, of uric acid, and of earthy phosphorus, are extremely distinguished from each other, and from all others. They are white, as it were cretaceous, friable and semi-transparent, according to the nature of the enveloping phosphorus, has a base, an ammoniaco-magnesian base,

tutes its two principal varieties. The uric acid forms their nucleus, and when they have been sawed, these two kinds of very distinct matters are found in them; the one at their centre, and the other without. They cannot be known until after they have been sawed. They are by no means uncommon; we have found them to amount to about a twelfth of the number which we have hitherto examined. They are also the most voluminous of all the urinary concretions; they vary from the size of a hen's egg, to a volume which occupies the whole bladder, and even considerably distends it. Their form is ovoid in general; frequently they are more pointed at one end than at the other. They are never prickly at their surface; there are frequently seen in them crystals of ammoniaco-magnesian phosphate: sometimes the central uric acid is covered in them with alternate layers of calcareous phosphate, and of ammoniaco-magnesian phosphate. Their specific weight is very variable.

41. In referring to the fifth species, the urinary calculi composed of uric acid, and of earthy phosphates intimately mixed, I observe, that it is in this species that the most numerous varieties are found, on account of the respective proportions of the three materials of which they are constituted; for a single earthy phosphate has never yet been met with in it, but always a mixture of phosphate of lime, and of ammoniaco-magnesian phosphate. It is not only by the diversity of proportion between these three materials, and by that of the animal matter, that the

the varieties of this species ought to be reckoned, but also according to their respective arrangement. Sometimes, in fact, the two principal matters, the uric acid and the earthy phosphates, are separated into very thin layers, slightly distinct, but alternating from the surface to the centre, never however sufficiently distinct and unconnected, to be comparable to the preceding species; sometimes the layers of these matters are so fine, and so intimately mixed, that the eye can scarcely discern their difference, and that the analysis of each of these layers is necessary, in order to ascertain the presence of both of these materials. This is the reason why the calculi of this species, which in general are of a grey colour, frequently of a homogeneous texture, sometimes presenting strata of colour distinct or shaded between the fawn and the white, differ so much in their colour, their size, their form, and the number of their strata. Their colour is never so marked as the white of the pure phosphates, the fawn or reddish colour of the uric acid, the brown or dark-grey of the oxalate of lime; it is frequently veined, as it were marbled, disposed as in the onyx: frequently also it is of a smooth, as it were saponaceous or steatitious aspect. Some are found, in which the ammoniaco-magnesian phosphate is deposited in small crystalline grains, without any very distinct strata or beds; their form is most frequently ovoid, or irregularly spheroidal; their exterior is almost always friable, whitish, of a cretaceous appearance

ance, so as to suggest the idea of their being phosphate of lime alone: they are only well ascertained by sawing them. It is this mixture which most frequently forms the numerous polyhedral calculi, worn by friction against each other. This species of calculus is pretty frequent; the totality of the analysis has presented us about a fifteenth of them. Their specific weight varies greatly: the lightest was 1,213, and the heaviest 1,739.

42. The sixth species, formed of urate of ammonia and earthy phosphate, in distinct and well defined layers, approaches much to the fourth species in its external appearances; it presents two matters, the one forming the nucleus, is most frequently of ammoniacal urate; the second inclosing the first, is rarely formed of ammoniaco-magnesian phosphate alone, but most frequently of the two earthy phosphates mixed together. Sometimes the ammoniacal urate of the centre is itself mixed with phosphates; sometimes the external layers of phosphates contain a small quantity of this urate, which is itself, in some varieties, mixed with pure uric acid. It is distinguished from the calculi of the fourth species, only by the paler colour of the ammoniacal urate, by the layers of this salt, separable from each other, and particularly by analysis. It differs especially from the fourth species by its size, which is almost always smaller; its specific weight varies between 1,312 and 1,761. It is less frequent than most of the

preceding species; among six hundred calculi which we analyzed, we did not find one-twentieth of this species.

43. The same salts, ammoniacal urate, and earthy phosphates, intimately mixed together and not forming a nucleus with distinct surrounding strata, as in the preceding species constitute the seventh species, which greatly resembles the fifth in its external characters. It is distinguished from it by being in general less yellow, by being somewhat lighter, and especially by the circumstance, that when the calculi are treated with pot-ash, which dissolves their uric acid, much ammonia is disengaged from them. The calculi of this seventh species are rare: we found that they scarcely amounted to a fortieth part of those which we analyzed. In examining them carefully there are frequently found in them, alternate strata of urate of ammonia, of phosphate of lime, and of ammoniaco-magnesian phosphate, but so thin and fine, that they cannot be distinguished without much attention. Generally even, and this is what particularly characterizes this species, the layers of ammoniacal urate are not without a mixture of phosphate, as appears from analysis, and it is equally rare for those phosphates to be without a small quantity of ammoniacal urate. These calculi are never so large as those of the two preceding species.

44. Th

44. The eighth species of calculus which I distinguish, is formed of the two earthy phosphates mixed together; namely, the phosphate of lime, and the ammoniaco-magnesian phosphate. This species is very well characterized, and very easy to be distinguished by its pure white colour, without any admixture of yellow, fawn, red, or blackish grey. Its friable nature, its insolubility by the alkalies, its solubility even in the weak acids, also characterize it with certainty. The varieties of this species, which is sufficiently numerous, since amongst six hundred calculi that were examined, nearly forty of them were found, are distinguished by their bulk, which is sometimes enormous, by the irregularity of their form, which is rarely round, frequently unequal externally, by the appearance of a rapidly-formed concretion or incrustation, by a texture formed of white opaque strata, easy to be crushed, that whiten all stuffs like chalk, sometimes mixed with or interrupted by other more dense, semi-transparent, and spathose layers, or by real transparent crystals of ammoniaco-magnesian phosphate. The analysis, whilst it presents only these two salts, exhibits a great variety of proportions between them, but never only a single one of them, as I have already observed. Of this species are the concretions, in deposition or in incrustations, which are constantly formed upon the foreign substances, introduced through the urethra into the bladder. Their specific weight varies from

1,138 to 1,471. They form in general one of the lightest species of the urinary calculi.

45. I rank in the ninth species, the mixed calculi, containing in the centre a mural nucleus of calcareous oxalate, covered with uric acid, more or less abundant and thick. Externally, they are not distinguished from those of the first species, as both present the same appearances, the same varieties of form, colour, and of surface. They are known only by sawing them, and thus exposing their centre. The dark-grey or blackish-brown, stellated or radiated figure of their moriform nucleus, the fawn-coloured, yellow, or reddish layers of uric acid which cover it, afford them at the first aspect, an accurate and certain knowledge of their nature. The same varieties are found in them, as in those of the first species. Their specific weight varies from 1,341 to 1,750; these two extremes are so remote from each other on account of the great variety of proportions of the two constituent materials which they contain. We may even distinguish these varieties by the section, according to the relative thickness of the layers. More frequently the oxalate of lime in them, is completely, or entirely surrounded and covered with uric acid and occupies the centre, so that its presence would not be suspected, from the external appearance of the calculi. Sometimes the nucleus of mural oxalate is excentric placed at one of the foci of the ellipsis of the calculi, which

have this elliptical form ; so that the moriform tubercles come on one side, as far as the outer part of these calculi, and there form spots or kinds of projecting buttons, which render their surface rough or mottled at this extremity. This variety is much less frequent than that of the preceding structure: amongst six hundred calculi, twenty presented themselves of this species, and amongst these, only four had the oxalate in an excentric situation.

46. To the tenth species, belong the calculi composed of oxalate of lime and earthy phosphates; the first placed at the centre and forming the nucleus, the second enveloping the oxalate of lime, and presenting themselves at the exterior part, so that they might be confounded by their aspect, with the fourth and eighth species, if their interior were not examined after sawing them. When it has been once opened, this species can no longer be confounded with any other; the exterior white, and as it were, chalky strata, enable us to recognize it with facility and certainty. Next to the calculi of pure uric acid, those of this species have presented themselves to us; almost the most frequently in our analysis. They form about a fifteenth of the number of calculi, that we have examined. Their size and form vary remarkably; their external colour is always white. Frequently, their oxalate of lime is placed in an excentric situation; however, it rarely extends itself to the outside of the calculus.

culus. The specific weight of these calculi is likewise very variable: I have found them to weigh from 1,168 to 1,752.

47. The eleventh species is formed of the mixture of three or four calculous materials, namely, of the uric acid alone, or mixed with urate of ammonia, of oxalate of lime and earthy phosphates. This is one of the least common calculi, since amongst six hundred, we have only found eight or ten of them. This species frequently presents three very distinct strata, the centre or nucleus of oxalate of lime, the intermediate stratum of uric acid, or ammoniacal urate, and the exterior of earthy phosphates, generally mixed with uric acid, or ammoniacal urate. It can only be known by sawing it, as its surface presents only phosphates; there is reason to believe, that calculi will be found formed of these three or four matters, mixed together more intimately, and not distinguishable by the diversity and separation of their strata. Three principal varieties of this species may be distinguished; that which is formed of oxalate of lime, of uric acid, and of phosphates; that which contains urate of ammonia, mixed with the two other matters, without free uric acid, and that, which, with these two matters, contains at the same time both free uric acid, and urate of ammonia, mixed with earthy phosphates. We might also separate these calculi into those with distinct strata or with three or four matters, intimately mixed together

together, those in which the pure phosphates envelope the two other matters, and those in which the phosphates are themselves mixed with uric acid, or with urate of ammonia, and even with these two bodies together. We have found some of all these kinds; but these distinctions, which might still be multiplied, are too refined, and of too little importance for the purposes of the art. It is sufficient to remark, that the more the component parts are multiplied, the more numerous the varieties of their mixture must be.

48. Finally, I place in the twelfth and last species, the calculi of complicated composition, in which the silex seems to hold the place of the oxalate of lime; these are mixed with uric acid, and urate of ammonia, and is covered with earthy phosphate. I make a particular species of these, on account of the presence of the silex, an unexpected matter, in some degree, foreign to the urinary concretions. Though this singularity seems to authorize the distinction which I here admit, I must, however, observe, that these calculi, in part siliceous, approach nearly, in their composition, to the preceding species. This is the rarest species of all; amongst six hundred, we have met with only two of this nature. It may also contain oxalate of lime; and thus constitute a calculus, which contains all the calculous materials hitherto discovered.

tions since these two facts prove, that it may be found in them ?

55. If I were inclined to pursue the same reasoning upon each of the twelve species of calculi, which I have distinguished, it would be still more embarrassing to determine the causes, which occasion to be deposited, almost at once, or in very close, and very varied layers, the uric acid, the urate of ammonia, the oxalate of lime, and the earthy phosphates, which appear, especially in the eleventh species, to be intimately mixed, and consequently to be separated together from the urine, to form those complicated concretions, which combine in themselves all the calculous materials. It is sufficient that I have pointed out, how many observations remain to be made, and inquiries instituted ; and what minute and persevering attention, is requisite in this branch of the art, which has acquired so new an aspect, since our analysis of the calculi. The chemical examination, and the exact analysis of the urine of calculous patients of different ages, and in different circumstances, can alone satisfy all these important questions ; and already, investigations of this kind, have presented to us, some happy results, which I shall indicate, in treating of the lithontriptics, or the means of dissolving the calculi of the bladder.

they might deposit themselves, in order to give rise to the calculus of the kidneys, and of the bladder.

50. This is in fact, proved by the two frequent circumstance of extraneous bodies, introduced into the last-mentioned organ, and even into the urethra. But we have observed, that in these cases, the accidental, and in some sort, artificial calculus which is formed, is almost always white, and composed of earthy phosphates. All urine indeed contains uric acid, and consequently that which forms the most frequent species of calculus; however, the nuclei introduced from without, hardly ever becomes covered with it; and it is remarked, that the individuals, in whom this uric calculus is met with, never present it, except formed upon an interior nucleus, upon a gravelly original that has descended or fallen from the kidney. It is therefore necessary, that there should be a particular cause to give rise to this formation. Undoubtedly, the superabundance of uric acid, which takes place in calculous subjects, its production in greater quantity than in the natural state, must be allowed to be the first, and most certain of these causes, especially when we consider the rapidity with which this calculus frequently increases. But this cause alone is not sufficient; and if it existed insulated, we should see in it only a source of precipitation of the urine, without finding in it, that of the concretion, and the tendency to form solid layers.

51. More-

51. Moreover, there is required the presence of a coagulating matter, which had formerly been distinguished as lapidific, and which being abundantly dissolved in the urine, is at the same time, extremely disposed to separate, and precipitate itself from it, carrying along with it, and glueing together the solidifiable, and frequently crystalline particles, which are at the same time, separated from it. This is undoubtedly the animal matter, that is found in all the calculi, of whatever nature they may be; for it constantly exists with one or other of the calculous materials, as we have found it in all these materials. It is this which forms the connecting part, or the ground-work of the calculi, in the same manner as the membranous gelatine forms the primitive organ of the bones. This is so true, that the urine of calculous patients is generally thick, ropy, mucous, and as it were, charged with glairy matter; and, that when it does not present this character, immediately after being voided out of the bladder, it speedily assumes it, either at the same moment when the ammonia is formed in it, or by the addition of the alkalies, which separate this animal substance from the acid which appears to hold it in solution.

52. It seems besides, that in all the cases in which the uric acid is very abundant, the urine at the same time contains a large quantity of the animal matter, which accelerates its precipitation, which attracts it in its separation, and which

which closely agglutinates its particles. Hence it follows, that all that is capable of augmenting the proportion of this species of mucous gluten in the urine, may be considered as a remote cause of the formation of the urinary calculus; and thus all the ancient notions of the physicians, respecting the pituitous temperament, and the abundance of glairy matter, which they considered as tending to the production of calculi of the bladder, upon the ground-work or the gluten of stones, or animal concretions, correspond in an exact manner, with the new notions, which the analysis of the urinary calculi affords at present, respecting the nature of these concretions. Though there is a real difference between the animal matters, contained in the urinary calculi of different compositions, it is nevertheless certain, that each of the calculous substances, containing an animal gluten, to which it owes its concrete and solid state, we cannot refuse to consider this superabundance of agglutinating animal matter, as the first and principal cause of the formation of the calculi.

53. Amongst the causes which influence the formation of the urinary calculi, the most remarkable perhaps, and the most difficult to be discovered, is incontestibly that which relates to the diversity of their nature, and the difference of the successive strata, which constitute them. As yet, I know nothing at all respecting the production of the calculi of oxalate

lemonade, and to be hardly more acrid than the urine itself, soften and dissolve with even more rapidity the calcareous and ammoniaco-magnesian phosphates. These native matters, in fragments or strata of calculi, when suspended by means of a hair or thread in the above-mentioned liquors, melt, become lighter, rise towards the surface, and soon leave in their place only some transparent flakes, similar to the mucous lamellæ, which float upon the surface of the liquor. The presence of the uric acid, dissolved in the ley of potash, is demonstrated by the addition of a weak acid, and even of vinegar, which precipitates it in a white powder; and that of the phosphates in the acids, by ammonia, which separates them.

As to the calculi of calcareous oxalate or the mural calculi, they are the most difficult of solution by weak re-agents. They, however, become soft and even melt almost entirely, with the exception of a spongy and brownish animal matter, in the nitric acid diluted with water; but they require a much longer time for their solution than the preceding. We may also effect their solution in a ley of carbonate of potash or soda, which decomposes the calcareous oxalate by double elective attractions; carbonate of lime is deposited at the bottom of the liquor, which retains the oxalate of potash or of soda in solution.

59. One or other of the liquid re-agents that have been indicated, when injected into the bladder of a calculous patient, must therefore act upon the urinary calculus and effect its solution, if nothing opposes its effect. Nevertheless, in this injection of the lithontriptics or solvents of the calculi of the bladder, three kinds of difficulties present themselves, which it is necessary to know and to appreciate in order to endeavour to remedy them. The first, is to determine the nature of the calculous existing in the bladder. The variety of these concretions, even that of the different layers which so frequently form them, seems to oppose an obstacle to the success of these solvents, the employment of which cannot be advised, nor a proper choice made till after the calculous substance upon which we wish to cause them to act has been determined. The second consists in the necessity of preventing any action of the solvent upon the bladder, and confining it solely to the calculus; the third relates to the mixture of the re-agent with the urine, which may modify it, annihilate its effects, or accompany them with some inconveniences detrimental to its action upon the calculus. Let us consider each of these difficulties, and prove that they do not present an insurmountable obstacle to the solution of the urinary calculi in the human bladder.

60. We have but few means of determining from exterior indications the nature of a calculus

les contained in the bladder. Sounding with the catheter affords pretty accurate indication of its volume, its hardness, its uniform or rough and fretted surface, but it discovers nothing with respect to its composition. No symptom as yet furnishes the slightest notion on this subject: and in fact no regard has yet been paid in external or operative medicine, to the different component materials of the calculi: the idea of searching for lithontriptics has never yet been founded, as it ought to have been, upon the diversity of the nature of these concretions. In this absolute silence of the art upon this subject, we have thought that the examination of the urine of the calculous patients might afford some light respecting the species of their calculi, and we have founded our suppositions upon the circumstance that this urine ought to contain at least the substance which is incessantly added to the exterior of the vesical concretions. The examination of the urine of two calculous patients has already presented to us either very sensible diminution, or an almost total absence of the uric acid which is generally contained in healthy urine: and we have therefore concluded that their calculi were formed of this acid. In one of them, who died of aguish and weakness, the opening of the body actually presented to us a calculus of uric acid. But this point is still new, and ulterior researches are necessary in order to confirm or invalidate this supposition.

61. The gravel voided before or after the symptoms of the presence of calculus in the bladder, may also afford a notion of the nature of this calculus. We may also derive information from the calculi which the parents, children or brothers in the families of the patients, have either evacuated naturally, or which have been extracted from them by an operation. For it is reasonable to believe that the hereditary disposition to this disease proceeds from a uniform cause in such families, and consequently that the calculous matter is general or of the same nature in them. It is here to be observed that the uric acid and the ammoniacal urate being the most frequent of all the calculous materials, and being, as it appears, at least in the proportion of a third of the whole of these concretions, whilst the two other thirds are composed from among the three other calculous matters, the two earthy phosphates and the oxalate of lime (for the filix, is so rare, that it ought scarcely to be reckoned amongst these materials); it is evident that the ley of pot-ash will most frequently be the proper solvent to be chosen. Moreover the use of this ley in injection cannot long leave us in uncertainty with regard to its effect, and consequently with regard to the nature of the calculus. The diminution of the symptoms which it produces, and that of the volume of the calculi, which may be ascertained by founding, soon show whether the right solvent has been

been chosen. In the contrary case, recourse to be had to the acids.

62. There is another method of ascertaining the nature of the calculus contained in the bladder and of the solvent that ought to be injected. It is that of examining this solvent after the first injections, and after it has remained for quarters of an hour in the bladder. First a very weak ley of pot-ash be employed, which has however been previously found able to dissolve the uric calculus, by suspending one a ley of the same kind out of the body; let it be collected half an hour or three quarters of an hour after it has remained in the bladder; let it deposit some flakes which it generally contains, and of which I am immediately about to speak; or let it be filtered through a sized paper, and let a little muriatic acid be poured upon it. If this ley has met with a calculus of uric acid, and if it has begun to dissolve it, the addition of the acid will produce in it a sensible white precipitate. This experiment continued during several successive days, and at each of the injections, must ascertain in a positive manner the acid nature of the calculus; and it may even be conceived that if it were constantly performed upon all the portions of alkaline ley injected into the bladder, we might determine the quantity of this acid taken each day from the calculus, and go on as far as the happy moment, when the patient, being also freed from the embarrassing symptom arising from the existence of this body, and

the catheter no longer announcing its presence, the injected liquor must cease to indicate the uric acid, and show with certainty the complete solution of the vesical calculus.

63. It is easy to conceive, that if the alkaline ley at its discharge from the bladder, does not give any trace of uric acid; if after its action has been continued for some days, it persists in presenting none; if the symptoms remain obstinate in all their intensity, there is reason to believe that the calculus is not formed by this acid, and we are authorized to direct our views towards the injection of the weakened muriatic acid. This, as it acts very speedily upon the phosphates, if such is the nature of the calculus, or of its exterior strata, will soon present the proofs of its action. When tried, after its discharge from the bladder with some drops of ammonia or pot-ash, it will give a white precipitate of phosphate of lime, abandoned by the acid, in proportion as the added alkali saturates it. The relief produced by the speedy diminution of the calculus, will, in this case, quickly follow the action of the injected acid; for our experiments show us, that of all the calculous matters, the earthy phosphates are the most speedily soluble in the muriatic acid. If two matters disposed alternately, form the calculus, for instance, the earthy phosphates without, and the uric acid at the centre, which happens pretty frequently, the action of
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the acid injected, will cease at the end of a certain time; this will be perceived by examining the liquor, after its discharge from the bladder, and by its not being precipitated on the addition of ammonia; it will then be necessary to have recourse to the alkaline ley, in order to complete the solution of the acid nucleus of the calculus.

64. The discovery of the mural calculi of calcareous oxalate, contained in the bladder, is still more difficult than that of the preceding; the urine is not susceptible of exhibiting any other indications of them, except its turbid nature at the moment of its discharge, and the analysis, by which we must find the oxalate in its precipitate. But no urine of this kind has yet been met with in calculous patients, or at least, none has been analyzed. Without denying that this may exist, especially in the urine of certain calculous patients, which is discharged white and turbid from their bladder, we shall not be able to confirm this notion, except by an examination, pursued for a sufficient length of time, of these excrementitious liquids, in persons afflicted with the calculus. Such an examination cannot be made, with the attention and the series of experiments, which it requires, except in a house destined for researches of this kind. It will be in this manner, that we shall be able to ascertain, whether the presence of an oxali-calcareous calculus, is capable of being ascertained

ascertained in the bladder of a calculous patient, by the analysis of his urine; and whether the nitric acid and the carbonate of pot-ash, injected into this organ, will be capable of effecting its solution, as we have seen these solvents act out of the body, upon the mural and oxalic calculi, which we have suspended in them. Such inquiries are too interesting to humanity, not to induce us to hope, that they will sooner or later, be promoted by the public power, and that a national establishment will one day be consecrated to them.

65. It has been feared, and not without some appearance of reason, that liquors capable of acting upon such dense urinary calculi, the solution of which has so long been considered as impossible, might first exert their energy upon the coats of the bladder, and disorganize or destroy it, instead of dissolving the concretions, which this membranous and muscular viscus contains. Such an unfortunate occurrence, which is asserted to have taken place in some imprudent trials, in which too highly concentrated alkaline leys, or acids, have been employed, is however, not difficult to be avoided, and the following are the precautions which we have taken for the purpose. The solutions of pot-ash, or the acid liquors, were so much diluted with water, so much weakened, that they not only had merely a slight taste, very easily supportable in the mouth, but that
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their acrimony was also not more sensible than that which characterizes the urine, in order that the delicate structure of the bladder might sustain no injury from their active property. Thus I have already seen five persons use alkaline injections, without experiencing pain, fatigue, or even any sensation, which could either have apprised them of the presence of a matter, different from the urine in this viscus, or have afforded ground for the least apprehension, on account of the stay which this solvent had made in it. I have observed, that the acidulous muriatic injection, though as weak as lemonade, was always more sensible to the bladder, than that of the alkali, and that it excited a propensity to make water, and an irritation, an excitement to contraction and spasm, which did not permit it to remain there for so great a length of time. But fortunately, this acid, even when reduced to extreme weakness, easily dissolves the calculous phosphates, and it is not necessary that it should remain so long in the bladder as the alkali, the action of which, upon the uric acid, is slower, and more difficult.

66. A third consideration respecting the solvents of the calculi, has for its object, the influence which these solvents exercise upon the urine, and that which they may receive from this liquid. In former discussions, similar to this, it has been presumed, either that the urine op-
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posed their solvent and lithontriptic quality, or that it was precipitated by them in such a manner, as to become more calculous, giving reason to apprehend, rather the augmentation than the diminution of the calculi; or at least, causing the precipitate which they occasioned in it, to be unjustly considered as the matter taken from the calculi themselves. In fact, that the alkali must find in the urine, free phosphoric and uric acids, which would absorb and saturate it, sooner than suffer it to act upon the calculi: accordingly, the urine must be an obstacle to its solvent quality. But there are two means of removing this obstacle to the success of the lithontriptics: the one is, not to inject the alkaline ley, till after having evacuated all the urine contained in the bladder, and after having washed it with luke-warm water. Then this ley can only be weakened by the urine, which shall arrive by the ureters, and this effect may be diminished by the second means, which may even cause it to cease altogether, and which consists in giving the calculous patient caustic pot-ash, extremely diluted to drink. Experiments made at Dijon and Paris, have already proved, that after the internal use of the pure alkali has been continued for some days, the urine ceases to be acid, is becomes alkaline, and thus acquires a character analogous to that of the injection, so as no longer to oppose its effect. It has even been hoped to give it by this means a sufficient degree

degree of alkalinity to render it a solvent of the calculus, and thus to effect its solution : though it may be very difficult to obtain complete success by this means, at least upon calculi somewhat voluminous, I cannot, however, refuse my confidence to it, either for dissolving the renal calculi, curing the gravel, or preventing the augmentation of the calculi of uric acid, and giving to the urine, a character favourable to the action of the alkaline solvent, injected into the bladder.

67. The alkaline ley, injected into the bladder, when it meets with the urine, there produces still another effect in it, which embarrasses its operation. When this liquor is acid, in proportion as the ley saturates it, it separates from it a gelatinous matter, which the phosphoric acid rendered soluble in it, and which is precipitated from it in mucous flocks. These flocks, which I have constantly observed in the five subjects treated by this process, are sometimes in viscous filaments, similar to what is called glairy matter ; or they form small thick bodies, which collect about the eyes of the catheter, and greatly impede the passage of the urine, so that it is necessary to agitate this instrument, and introduce a filette into it, in order to remove this slight obstacle, and render the flow of the urine more free,

The very weak muriatic acid, injected into the bladder, has not this inconvenience ; on
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contrary, it gives more transparency and purity to the urine of calculous patients, than it naturally has; it even prevents the precipitation of the glairy matter, which is so frequently seen in it, and which especially accompanies the ammoniacal state of the urine, which is sometimes found in those patients, and in this very circumstance, it opposes the formation and the concretion of the ammoniaco-gnesian phosphate, for the solution of which it is especially employed.

3. The alkaline or acid liquors, destined to serve as solvents of the calculi of different natures, ought to be injected into the bladder, at a temperature of about 25 degrees. A catheter of elastic gum, and a tin syringe, are all the apparatus necessary for this operation. As the injections, repeated at first three or four times a day, afterwards six or eight times, and each remaining from a quarter of an hour to an hour at least, in the bladder, must be long continued, and consequently require a space of several months for dissolving these calculi, it is necessary that the patients should keep the catheter stationary, and use themselves to perform the injections without help. They will thus avoid the repetition of the pain, which is excited by the introduction of the catheter, especially in the organ irritated by the presence of a foreign substance, and much more sensible than in its natural state. They will soon become familiarized

shops, and collections of *materia medica*, under the name of occidental bezoars, are more commonly stomachal or intestinal concretions, than urinary calculi; I have examined about sixty of them, grey, greenish, and yellowish, and I have found in almost all of them, strata, easy to be detached from each other, on account of their polished surfaces, formed of crystalline filaments or lamellæ, like stalactites, having at their centre pieces of wood, fragments of bark, leaves, or small portions of branches, upon which their strata were deposited.

71. The observation which I have just mentioned, proves, that when we take the common and pharmaceutical bezoars, as subjects of analysis, we most frequently examine intestinal calculi, and that scarcely any is urinary or vesical. I never had but three well ascertained opportunities to examine this last species of calculus, namely that of the horse, that of the hog, and that of the bullock. The first were given me by veterinary artists, who had extracted them themselves, either from the kidneys, or from the bladder of horses that had died of disease. We are not to confound with these, the concretions sometimes very voluminous, which naturalists call hippolithes, and which are formed in the intestine of the horse: these are composed of ammoniaco-magnesian phosphate, and calcareous phosphate, whilst those of the kidneys and of the bladder of this animal, are composed of carbonate of lime, and soluble
with

phosphate, or of calcareous phosphate. Frequently, this last salt has been found in the acidulous state, in the analyses which I have made of them. Thus, there exists an essential difference between the intestinal calculi, and the urinary calculi of animals, and this difference accords with that which also exists between the urine of these animals, and the human urine. As the first contains carbonate of lime, instead of the earthy phosphates contained in the second, the deposition which it forms in its canals, is only the first of these salts, whilst in the human bladder it is frequently composed of phosphates. But animals are much more subject than man, to concretions of the stomach and intestines, and these concretions are constantly owing to depositions and crystallizations of earthy phosphates, occasioned by these salts being more abundantly diffused, and as it were, cantoned in the organs of digestion, in these beings, whereas in man they are determined towards the urinary passages, which are their natural emunctory.

75. A still more singular difference is met with between the urinary concretions of animals, and those of man. In the first, we find nothing similar to the uric acid, which is the most abundant and most frequent of the materials of the human calculi. It appears that this singular matter is exclusively prepared, and formed in the body of man, though its constituent principles equally exist in that of all the

animals. The cause of the peculiarity of this formation to man, must consist in the difference of his organs, and of his liquids; but we have as yet, too little knowledge respecting this difference, to be able to explain upon what this exclusive property depends. We are not even acquainted with the relation which must subsist between the humours of the human body, and the uric acid, which proceeds from the alteration of some of them. Perhaps indeed, it may be formed also in animals; perhaps it may be contained in their urine, but in so small a quantity, that it has hitherto escaped the most careful analyses. The discovery which Citizen Vauquelin has made of a small quantity of uric acid in the bladder of a tortoise, should seem to authorize this last opinion. Perhaps also, the uric acid will at some future time be found in the body of animals, but in some other organ than the kidneys, or in some other liquid than the urine. This acid has been thus met with in man, in other parts besides the urinary organs, as I shall show hereafter.

76. The oxalate of lime, the most frequent material of the human calculi after the uric acid, is in the same predicament with this acid. I have not yet found it in the calculi of animals, or in the bezoars which I have been able to examine. It would not however be accurate, absolutely to deny its existence in these concretions; I have as yet analysed too few of them, and there are too many sensible or exterior differences between these bezoars.

which I knew only by eye-sight, not to lead me at least to suspect, the possibility of the existence of the oxalate of lime, in some of those oriental bezoars, whose hardness, polish, and dark colour, seem to approximate to some specimens of those hard and brilliant moriform calculi, which I have pretty frequently found in the human bladder. Though it is not easy to comprehend the formation of this salt in the urinary passages of man, as the chemists had hitherto believed it to be foreign to animal matters, and as they had found it only in some vegetable matters, it is no longer difficult to admit the possibility or probability of this formation in the bodies of animals.

From these considerations it follows, that the analysis of the urinary concretions of animals, compared with those of man, and extended to the concretions which frequently exist in them as well as in man, in other regions, besides the kidneys and the bladder, becomes of great consequence in the physiology of animals, and, that it ought to be strongly recommended to those who possess such rare subjects, so difficult to be collected by a single individual.

SECTION VIII.

Of the Arthritic Concretions of Man.

77. I HAVE several times pointed out in some articles of this section, devoted to the analysis of the animal matters, that medical men, resting upon numerous observations, had found striking affinities between the diseases of the urinary passages and the gout. It is especially with the calculi of the human bladder, that this analogy has been very often announced. In fact, we frequently see long attacks of the gout, followed by the gravel and the stone, and it is not uncommon to find calculous concretions in the kidneys and the bladder of gouty old persons. Gouty parents have frequently children subject to the stone, and vice versa. Frequently also, persons subject to the gravel, experience a cessation of this complaint, at the same time that their joints are attacked with arthritic pains. After the ancients, Sydenham, Cheyne, I. A. Murray, and several other celebrated physicians of the last and the present centuries, have confirmed this analogy, which now is universally admitted.

78. As

78. As in all these cases, solid concretions, more or less prominent, are frequently formed round the articular capsules, and the extremities of the bones, which impede their motion, which frequently even render them entirely immovable, and which sometimes are of considerable bulk, since Severinus has described some as large as an egg, it was very natural for physicians to think, that the nature of these concretions was the same with that of the solid base of the bones, and we have seen that they had admitted the same opinion, respecting the substance of the calculi of the bladder, before Scheele had made the valuable discovery of the uric acid. In fact, the first experiments made upon the arthritic concretion, had sometimes indicated a resemblance with, and sometimes a difference from the bones and the urinary calculi. Schenkius said, that the arthritic concretion pulverized, assumed a consistence with water, like plaster. Pinelli, describing in 1728, some experiments upon the arthritic matter, said he had obtained from it by distillation, volatile alkali, and some drops of oil, as also a residue, weighing $\frac{1}{12}$. He could not dissolve it in the oily ammoniacal liquors, which he employed, though he could in the sulphuric, muriatic, and even acetous acids. Nevertheless, Doctors Alston, Whytt, F. Hoffman, and Boerhaave, have recommended the use of alkalies and lime-water in the gout, as well as in the stone. These data, which are
contra-

contradictory to the first result of Panilli, only produced uncertainty respecting the gouty matter: Cajetan-Tacconi also, after an examination, though a very superficial one, of the sinovia of gouty patients, and from its effect, of sometimes turning the syrup of violets green, and sometimes red, has concluded that the gout was either acid or alkaline, and that it arose from this double cause. Such a conclusion could only embarrass still more the theory and the practice of the art.

79. After the discovery of Scheele, respecting the acid nature of the most frequent of the urinary calculi, there was reason to hope for some more decisive experiments upon the arthritic matter. Yet we find but a few essays upon this important object, in the twenty years which have elapsed since this period. We read in the memoirs of Stockholm, for 1783, an observation of Mr. Roering, from which it results, that some concretions expectorated by a gouty old man, were phosphate of lime; but I have already elsewhere remarked, that the pulmonary concretions were formed of this salt, and it is very evident, that these calculi must be independent of the arthritic matter. Mr. Watson has published, in the medical essays of London, Vol. I, 1784, (medical communications) an examination of the arthritic concretion, taken from the dead body of a gouty person, from which he has concluded this matter to be very different from that of the calcu-

ius, since it dissolved in sinovia, and mixed easily with oil and with water, whilst the calculous substance presented properties entirely the reverse. But this difference might depend upon the state of combination of the calculous substance; and this has been discovered to be the case by Mr. Tennant, of London, who announces, that the arthritic concretions are composed of the acid of the calculus, combined with soda.

80. This simple notice, inserted in some periodical works, appeared to me of so great importance to the progress of the art, that I ardently wished to confirm it, by a correct experiment. Several years elapsed without my being able to satisfy my wish, as it was impossible for me to procure arthritic concretions, though I had applied to several physicians for them. It was not till towards the month of Vendimiaire, in the year seven, that a favourable opportunity presented itself, for which I am indebted to Citizen Veau, a physician of Tours, professor at the central school in that town, and equally distinguished for his learning and his ardent zeal, for the progress of the healing art. This physician, who is fully sensible of the value of correct chemical researches, applied to the phenomena of the arthritic economy, brought me acquainted with a patient who had been afflicted with a stone in the great toe of the right foot, who, to judge

judge from the swelling of different articulations, seemed to carry in this manner, in the whole of his body, more than a kilogramme of this concrete matter.

81. This patient, whose feet, hands, and knees are tumefied, experiences no pain in most of these regions, when the skin is touched. Their arthritic concretions are every where adhering to the bones. As to that which is situated at the last phalanx of the great toe of the left foot, and from which the portion which has been sent me, proceeds, the tumor is about thirteen centimeters in circumference; it is ulcerated and open at its superior and outer lateral part; it daily discharges a fetid pus, which has not been examined, but which appears to carry with it a portion of concrete arthritic matter. For a year past, the patient suffered excruciating pains; he scarcely slept a few minutes, without being wakened by the violence of his disease. For several months past, he had not quitted his bed, and he frequently emitted piercing cries. The part of the podagric concretion, which was transmitted to me by Citizen Veau, with the details which I have just given after him, had been extracted from this ulcerated tumor, to the opening of which, it had been propelled. I have subjected it to the experiments which its small quantity permitted me to try; they were made in the presence of the enlightened physician, to whom I am indebted for it.

82. This

82. This whitish, irregular concretion, finely granulated as it were in its texture, much resembling in appearance, a broken piece of officinal agaric, was about four centimeters in extent; it weighed more than three grammes and a half. It was porous and light; it could not be triturated in a mortar, without difficulty, on account of the abundant membranous pellicles, with which it was intersected; it cut after the manner of tallow, and the parts exposed by the section, were polished and brilliant, like the laminae of spermaceti. Heated by a pretty violent trituration, it exhaled a faint animal odour. A gramme of it, heated in a silver crucible, exhaled a white, fetid, empyreumatic, and ammoniacal smell; it burned without softening, although it swelled into bubbles, the crucible, taken from the fire after the cessation of the smoke, presented a blackish residuum, of an alkaline and bitter taste, analogous to that of an alkaline prussiate, weighing a sixteenth of the mass employed. Distilled water poured upon this residuum, dissolved a part of it, and gave with the sulphate of iron, a blue precipitate of very fine prussiate. It therefore contained a fixed alkali, and a very abundant animal matter.

83. Treated with a hundred times its weight of water, by an ebullition of some minutes, it almost entirely dissolved in this liquid, becoming covered with a froth, like that of a ley of soap, and exhaling a faint animal odour, similar

lar to that which proceeds from skin, membranes, tendons, and ligaments, when boiled in water. There was only about a tenth part of the concretion that was not dissolved. This part was like swelled membranous pellicles. The sulphuric acid poured into the solution, produced in it a white pulverulent precipitate, which in collecting, assumed the form of small crystalline needles, very distinguishable for being the uric acid. The supernatant liquor, gently evaporated, exhibited crystals of sulphate of soda, difficult to be obtained from it, well separated on account of the viscous and gelatinous state, which the evaporation had produced.

84. A portion of the arthritic concretion equal to the two preceding, was treated with more than a hundred times its weight, of a concentrated ley of pot-ash, assisted by heat. It was almost completely dissolved in it, exhaling the faint animal odour already indicated. The liquor filtered, in order to separate from it some undissolved flakes, was mixed with weak muriatic acid, which formed in it a white precipitate, similar in its aspect and all its properties, to the uric acid, and very recognizable for this species of acid. Immersed in a very weak ley of pot-ash, a part of this concretion was softened, and lost all its consistence, without losing its form; uric acid was afterwards precipitated from the liquor, by the addition of muriatic acid. The arthritic concretion

cretion therefore resembled a urinary calculus, formed by the uric acid excepting that the proportion of animal matter in it, appeared to be more considerable than in the latter.

85. These experiments evidently prove, that the arthritic concretion in question, is formed of a mixture of urate of soda, and of gelatinous animal matter; they confirm what Mr. Tennant had announced. They nevertheless indicate, that this salt, which has not yet been found in the urinary calculi, and which contains only the uric acid, combined with the soda, so frequent in the animal liquors, is enveloped or accompanied in it with a mucous substance, which greatly exceeds its own quantity. They shew a relation, which has hitherto been announced in a vague manner, between the gouty humour, and the urinary concretions; they prove that the arthritic concretion is deposited between the laminæ of the articular capsules, and that it is by separating these laminæ, and crystallizing between them with more or less rapidity, that they envelope and swell the articulations; that they produce pains more or less acute, on account of the drawings which they excite in the nerves, and in the lymphatic vessels. Thus the superabundance of the uric acid, its deposition, or its transportation towards the articular organs, the mucous capsules, the meshes of the tendons, appear to be the immediate cause of the gout. Citizen Berthollet has already ascertained, that the
urine

urine of gouty persons, does not contain phosphoric acid during the attacks of this disease: it would also be of importance, to inquire whether it be equally deprived of uric acid. This is a new career, which chemistry opens to medicine, and of which the latter science will undoubtedly avail itself. It will be equally interesting to determine, why this uric acid is united with soda in the arthritic depositions, whilst it has not yet been found under this form of combination in the urine, a state in which, in fact, it cannot exist in it, on account of the free phosphoric acid which it contains.

ARTICLE XXVII.

Of the Liquor of the Prostate Gland, and of the Sperme.

1. THE prostate, a kind of flat, cordiform gland, situated between the most elevated part of the urethra and the rectum, to which it is attached by its superior face, of a firm texture internally, composed of many follicles pressed against each other, presents from ten to twelve excretory ducts, which open into the canal of the urethra round the eminence known amongst anatomists, by the name of *Crista Galli*, or *verumontanum*. This gland,

gland, which is the size of a large chestnut, and which is of a texture sufficiently dense to present a considerable resistance to the cutting instrument in the operation of lithotomy, secretes a liquid in small quantity, which is poured into the urethra by the apertures that have been indicated, and by the effect of the venereal orgasm, sometime before the seminal liquid. Its discharge, which only takes place by a kind of exudation, and never, or only very rarely by jets, is accompanied with a pleasurable sensation, which eunuchs enjoy instead of that which is produced by the ejaculation of the semen.

2. A discharge of this liquor is occasioned in some men, by the pressure arising from the expulsion of the excrements, or of the urine, and it varies considerably in quantity, in different individuals. All that is known respecting its properties, reduces itself to its whitish colour, its thick and viscous state, its faint animal smell, and its soft lubricating quality. No chemist has yet undertaken to analyze it; some have contented themselves with observing, that it was susceptible of being coagulated by alcohol, and they have consequently believed it to be of an albuminous nature. It may be supposed to contain, like all the humours of this kind, soda, and phosphates of soda and of lime. Perhaps it is also charged with a certain quantity of gelatinous matter, as its homogeneous, equal, and as it were,

were, mucous viscosity seems to indicate. It appears that its real use is to lubricate the canal of the urethra, to facilitate the rapid passage of the seminal liquor, to unite with this liquor, to augment its volume, and perhaps even to modify its properties, though we are not yet able, exactly to determine the function which it performs in its union with the spermatic liquid.

3. The seminal liquid, or the sperm, is separated in the testicles from the arterial blood, which is conveyed thither by the spermatic arteries. The texture of this secretory organ, presents a series of vessels rolled together like thread upon a ball, which must produce a considerable retardation of the liquid, with which they are constantly filled. From this texture, the sperm passes into the epididymis, a kind of body applied to the upper part of the testicle, and somewhat different from it in texture. It is terminated by a solid and dense canal, which pours the liquid received by it into the two seminal vesicles, which are membranous bags, situated upon the neck of the bladder, and connected together by a cellular texture. Each of these vesicles is contracted into a canal, which opens into the urethra, at the two sides of the eminence called *verumontanum*, after having traversed the thickness of the prostate. The sperm is discharged with a very rapid motion, and is sometimes ejaculated

lated to a pretty considerable distance from the penis.

4. The spermatic liquor, which is not formed in man, and animals until after their growth is completed or far advanced, together with the superabundance of nourishment, which accompanies this circumstance of life, marks its production, by a period well characterized, and by very remarkable appearances. The region of the genital parts and the chin, become covered with hair, the voice changes and becomes hoarse, the figure becomes determined and modified; the mind of the individual who arrives at this period, acquires more activity and energy; the person becomes taciturn, melancholic, and morose, till he has satisfied the desire which nature has produced in him. It is well ascertained, not only that the formation of this liquor has a great influence upon the animal economy, but that its too frequent discharge, as well as its retention in its reservoirs, produce maladies, which are sometimes of a very severe kind. The first enervates the physical and moral powers, so as to degrade, and even brutify the individual who commits this imprudent waste; the second produces in the moral and physical functions, a derangement, a kind of weight and obstacle, which impedes, and seems to oppress them. A moderate evacuation proportionate to the desires, supports the health in that equilibrium which establishes, and fulfils the intention of nature, who has

provided for the re-production of animated beings, by the sentiment and the want of pleasure.

5. The spermatic liquor, at the moment when it is evacuated by an individual, of a good constitution appears to be a mixture of two different substances; the one, viscous, gluey, homogeneous, and whitish; the other thick, grumous, and opaque, in which many white, and as it were, silky filaments are perceived, especially when it is agitated in water. It diffuses a particular faint smell, which is found also in the leaf-buds of the chestnut, and in the anthers of many flowers; it is also found in bones and ivory when sawed, filed or rubbed; on which account the ancients called these parts spermatic. It has the property of becoming fluid and transparent, some time after it has been evacuated; its mucous nature, the seemingly animated particles, which can be perceived in it by the microscope; finally, the crystals which are deposited in it by its exposure to the air, were the only chemical facts collected, respecting this liquor, previous to the month of April, 1791; and it is known to how many hypotheses and theories more ingenious than true, those ideas had given rise. At this period, Citizen Vauquelin published, in the *Annales de Chimie*, a memoir upon the human sperm, in which he has described an interesting course of experiments. As this is the only skilful inquiry into this matter, with wh

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I am acquainted, I shall here give a sufficiently detailed account of it, to suffer none of the new and useful results, which this memoir contains to escape my consideration.

6. The sperm has a slightly acrid and irritating taste, which sensibly constricts the membranes of the mouth. Though its specific weight varies greatly, it is constantly more considerable than that of water, as it is always precipitated to the bottom of this liquid. When the sperm is agitated in a mortar, or upon porphyry, or even between two pieces of paper, it becomes frothy, opaque, thick, and tenacious, like a kind of pomatum. It appears that this phenomenon proceeds from the air, which interposes itself between its particles, and undoubtedly also from the evaporation of a part of its water, which permits an approximation and crystallization of the saline matters, with which this liquid is replete, as we shall soon see. The sperm, as it is discharged from the urethra, turns the syrup of violets green, precipitates the calcareous salts, and the metallic solutions, on account of the fixed alkali which it contains. As its thick and flocky portion loses its caloric, it becomes transparent and more equally consistent than it was before. Some hours after, the sperm becomes more fluid, which does not proceed, as had been believed, from the absorption of atmospheric air, since it diminishes in weight; besides which, this phenomenon takes place in close

9. When the sperm, reduced to a tenth of its weight, by complete desiccation in warm and dry air, is exposed to the fire in a silver crucible, it is softened by the first degrees of heat, assumes the yellow colour of bread crust, and exhales yellowish fumes, which have the smell of burned horn. At a stronger heat the fume becomes thick, the sperm is turned brown, swells, and grows black, exhaling a strong smell of ammonia. Removed from the fire when no more vapour is disengaged, and while the spermatic matter no longer undergoes any sensible change, the crucible contains a pretty voluminous coal, which, when lixiviated with distilled water, furnishes carbonate of soda amounting to almost a fourth of the sperm that has been dried. This coal, burned afterwards and completely incinerated, gives a white residuum, forming a third of the dry sperm, and possessing all the properties of the phosphate of lime. This kind of analysis by open fire is destined, as it is evident, to separate the two fixed substances contained in the sperm. It has convinced Citizen Vauquelin that this liquor contained one hundredth part of its weight of pure soda, and three hundredths of phosphate of lime. When we heat the sperm in a distilling apparatus, instead of employing an open vessel, we obtain water, carbonate of ammonia, and a small quantity of oil. The coal which remains, does not differ from that which has just been described. Citizen Vauquelin

quelin has not detailed the phenomena and the products of this distillation, undoubtedly, either because he has performed it only upon too small quantities to obtain very sure results, or because it has furnished him with none sufficiently remarkable and sufficiently different from what are obtained from all the animal substances in general to merit a particular description. With respect to the action of caloric upon the sperm, as it is evacuated from its ducts, it is only to be observed, that it accelerates its liquefaction, that it does not coagulate it like many other animal liquids, and that this consequently contains no albuminous matter.

10. The sperm that has not been liquefied by the air, and immediately after it has been ejaculated from the urethra, does not dissolve in cold water; when it is much agitated in this liquid, it divides into flocks in it, and communicates to it a slight opacity. The solution does not succeed better in boiling water; the thick matter becomes on the contrary more dense, shrinks together, and attaches itself to the rod which is used for agitating it. When the sperm has been exposed to the air and has become spontaneously liquefied, it easily unites with cold and hot water. Alcohol and oxygenated muriatic acid separate the spermatic matter from the water, in the form of white flocks. Pot-ash, soda, and ammonia, render the sperm miscible with water, but only when they are concentrated. Lime disengages ammonia from it only when

when the sperm has been for some time exposed to hot and moist air, which proves that the ammonia is formed during the decomposition of this liquid, and even in very large quantity. The acids have also a solvent action upon the sperm; even the weakest, wines, urine, exert this action in a sensible manner; the alkalies however do not separate it from this solution, nor in fact do the acids precipitate it from its alkaline solutions. The proof that wines and urine dissolve the sperm only with the aid of the acid contained in these liquors, is, that they no longer produce this effect when they are deprived of this acid by any means whatever. Accordingly, water reduced to the slightly acid state, to the same slight degree of acidity which these two liquids possess, by the addition of a small quantity of sulphuric acid, dissolves the sperm.

11. The oxygenated muriatic acid acts upon the seminal liquid in a manner very different from that of the ordinary acids. Instead of dissolving it, it coagulates it into white flocks, insoluble in water and the other acids. It produces this effect even upon sperm liquefied by the air. A large quantity of this acid liquid, poured upon the sperm, gives it a yellow colour, and renders it perfectly similar to the matter which is discharged in some gonorrhoeas, especially at the termination of this disease. At the moment when it exerts this action, its smell disappears

which indicates that the sperm absorbs the oxygen of the oxygenated muriatic acid, and that the coagulation of the sperm and its yellow colouration, proceed from this absorption. This effect is similar to that produced by the same agent upon the lachrymal humour, the nasal mucus and the bronchial juice.

Finally, the sperm does not decompose the salts of barites and strontian when it is recent, or when it has been kept in a well-closed vessel, or has liquefied ; but it decomposes them when it has remained for some time exposed to the air and when it has begun to deposit rhomboidal crystals. It is very evident that this decomposition then proceeds from the soda of the sperm having combined with the carbonic acid of the atmosphere, and formed a carbonate capable of acting upon the salts of barites and of strontian, by a necessary double elective attraction.

12. From all these facts combined, Citizen Vauquelin concludes that the sperm possesses some properties in which no other animal matter participates, and especially the following which form its specific characters. It is alkaline ; it spontaneously deposits phosphate of lime in crystals or irregular grains ; it becomes sour in hot and moist air ; it is insoluble in water in its natural state ; it dissolves in it both when it has been liquefied by the air and when it has been dried in it ; it is soluble in the alkalies and the acids, and they cannot be reciprocally precipitated by each other. By comparing all the results of his experiment together,

together, he found in a thousand parts of sperm, the following proportions of its constituent materials :

Animal mucilage	-	60.
Phosphate of lime	-	30.
Soda	- -	10.
Water	- - -	900.

He observes that the causes of several of the phenomena peculiar to this liquid are yet unknown, especially that of its liquefaction by the air, its insolubility in water, its solubility when it is liquefied, the state and the proportion of the phosphate of lime which it holds in solution, the crystallization of the latter. The mucous animal matter contained in this liquid is not less a kind of singular problem in its nature and properties. It is not albumen, and if it approaches more to the nature of gelatin, it also differs from it by very remarkable characters. It appears that it is the cause of the viscosity, the flocky state, the smell, the insolubility in water, the spontaneous liquefaction, and several other properties of the sperm; but nothing more can be said respecting its singular nature, as it has not yet been possible to insulate it from the other materials of the sperm and to examine it when separated. It would be interesting, for example, to know its alteration by tannin, &c.

Though Citizen Vauquelin's analysis of the sperm is full of curious facts, and even furnishes very new and entirely unexpected results, it must however be admitted, that it does not yet

give us any light respecting the properties of this humour, almost miraculous in its effects; and that we do not find in it any possible application to its fecundating power. In the same manner we have seen, in one of the preceding articles, that the cerebral medulla or pulp, with which some physiologists have compared the spermatic liquor, did not yet present in the albuminous nature indicated by its analysis, any fact capable of elucidating its functions.

ARTICLE XXVIII.

Of some Animal Matters peculiar to the Mammalia.

1. AFTER having treated, in the preceding articles, of the matters that are common to all animals, which constitute their bodies in general, and especially of those which belong to man, the method which I have adopted requires that I should speak of the substances peculiar to each order of animals. But it is not necessary that I should here consider the properties which appertain especially to the uses of each of them; it is only to compare them with those that have already been examined, to point out the relations and the differences which subsist between them, to indicate in a general manner what analogies or dissimilarities there may be in their properties;

properties; finally, to give an exact but concise idea of their nature, that they are here to be considered.

2. Amongst the matters which the mammiferous animals or the viviparous quadrupeds furnish to the arts, there are ten which particularly merit the attention of the chemist, namely: Ivory, the horn of the stag, horn, wool, musk, civet, castor, ambergrease, spermaceti, and the bezoars. It will be seen that I do not here enumerate a multitude of substances, either very well known and generally employed, or formerly considered as very valuable and now fallen into disuse; such as the flesh, the skins, the hairs, the claws, the fat, the intestines, the different bones, the teeth of several animals, of the hippopotamus, of the castor; the blood of some, that of the wild goat; fossil horns and teeth, the turquoises, the unicorn's horn, the elk's foot, &c. down to the excrements of the dog, formerly called *album greecum*. These last-mentioned matters have been introduced by credulity, ignorance, prejudice and quackery into medicine; but the lights of chemistry have gradually caused them to be rejected from pharmacy. I have selected the ten substances which are the most important by their properties, their multiplied and frequent uses, as well as by their nature. They will besides serve to elucidate the nature of those of which I shall not speak, and to which they are analogous.

A. Of Ivory.

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A. Of Ivory.

3. IVORY, which is so well known and so much employed, is an osseous substance of a fine close and homogenous texture, which belongs to the enormous teeth called the tusks of the elephant. This animal, of which at least two principal species are known; the *Elephant of India* with a concave forehead, molares marked with stripes, transversely undulated, with small ears; and the *Elephant of the Cape*, with a convex forehead, molares marked with transverse lozenges, with very ample ears, and of which the Mammoth of Siberia seems to constitute a third species, forms by itself a particular order of the mammalia, very well characterized by the absence of the dentes canini and the incisores inferiores, by the prolongation of the incisores superiores into tusks, by the flexible and sensible trunk which terminates its nostrils, by its extraordinary bulk, by its intelligence and the energy of its passions.

4. The ivory of the Cape or African elephant is chiefly preferred, both on account of the considerable bulk of the tusks of this species, and on account of its hardness and beauty. The fossil teeth which have not lost their solidity are also employed. This species of osseous substance has a texture, a colour, a fineness of grain and a hardness, which render it very useful in a great number

number of the arts. The net work of lozenge or rhomboidal areolae which is observed in the transverse section of these teeth, is a character by which ivory is easily recognized, and which distinguishes it especially from common bones, in which we see only longitudinal strata or rays. Ivory, when sawed or filed, exhales a disagreeable faint smell, much resembling that of the sperm. The beautiful polish which this substance receives, the brilliant whiteness which distinguishes it, the softness of the forms which it receives, the various colours which are communicated to it, and which adhere pretty strongly to it, are well known.

5. As to its nature, ivory is composed, like the bones, of a gelatinous matter and phosphate of lime. In the fire, it becomes black, is converted into coal, and even affords so black and so fine a coal, that it is particularly employed in some of the arts, by the name of *ivory black*. When distilled, it yields water, a thick oil, and carbonate of ammonia; calcined to whiteness it leaves pure phosphate of lime. The acids soften it; water, on the contrary, by long ebullition, extracts from it gelatinous matter, and thus forms a transparent and very white jelly. The real difference which exists between ivory and the bones is not yet known: it appears to consist in the different proportion of the two matters which compose this kind of solid texture. It would be useful, in investigating this subject, to examine the difference between the
enamel

enamel of the human teeth, and the osseous substance properly so called ; and that which exists between the teeth of the hippopotamus and the rhinoceros, which are sometimes employed for real ivory, and ivory strictly so called.

Of the Horns of the Deer.

6. WHAT is called in the materia medica and pharmaceutical chemistry hartshorn is called the antlers in natural history and the chafe. The deer is a mammiferous and ruminating animal well characterized by its two hoofs its four stomachs, its osseous horns which it sheds every year, its smooth hair, its short tail, its long and thin legs, its lachrymal duct at the anterior part of the eye, its eight dentes incisores in the lower jaw, their absence in the upper, as well as the absence of the dentes canini, and of the gall bladder. The two osseous excrescences or natural exostoses with which the forehead of the male is provided, have long been much employed under the name of hartshorn. These horns are round, and bear several conical antlers, the number of which varies according to the age of the animal, and serves to ascertain it. Immediately after they have sprouted out they are soft, provided with a hairy skin, full of blood-vessels ; but they soon harden, are deprived of their skin, and become compact and osseous.

7. All the experiments which have been made upon the horn of the deer, all the products which

which are extracted from it, all the uses to which it has been applied, prove that it is a real osseous substance, formed of a gelatinous matter and phosphate of lime. By boiling the shavings of hartshorn for a long time in water, a considerable quantity of light, mild, and insipid jelly is obtained from it. This jelly is extracted either for the nourishment of sick persons, or for the preparation of several medicines, or for that of some kinds of food, to which we wish to give this form.

When hartshorn is distilled, a reddish and ammoniacal water is obtained from it, which was formerly called *volatile spirit of hartshorn*; a thick, brown, and fetid oil; much carbonate of ammonia in a solid form, and soiled by a little oil; carbonated and oily hydrogen gas and carbonic acid gas. There remains after this distillation a coal which retains the form of the matter distilled, and which, after its incineration, furnishes a little carbonate of soda, carbonate of lime, and much calcareous phosphate.

8. As great use was formerly made of the different products of distilled hartshorn, each of them was rectified with much care. The ammoniacal water was distilled by a mild heat, by which means it was obtained much less coloured. This liquid was frequently combined with the succinic acid, in order to prepare the *succinated liquor of hartshorn*. The brown carbonate of ammonia was digested in a small quantity

quantity of alcohol, and by thus depriving it of the portion of oil which it contained, the *volatile salt of hartshorn* was obtained white. The oil produced in this operation, was purified with the greatest exactness; attempts were made to obtain it white, colourless, very volatile, and highly odorous, under the name of *Dip-
-d's animal oil*. Formerly, this was accomplished only by several successive distillations; subsequently they confined themselves to two or three distillations, taking care to introduce the oil to be rectified in the retort, with the aid of a long funnel, to avoid soiling its neck; for a single drop of brown oil would have sufficed to colour a very large quantity of white oil; only the first portions of the product were drawn off in this manner. Rouelle, the elder, having remarked, that only the most volatile portion of this oil was white, advised its distillation with water, in order to communicate to it only the temperature necessary for the volatilization of this portion. I have already remarked elsewhere, that this oil is very light, and very odorous; that it contains ammonia; that it turns the blue vegetable colours green, and acquires more or less brown colour, by the mere contact of the light.

9. Formerly a particular operation was performed, which was named, *hartshorn philosophically prepared*. It consisted in suspending funnels at the top of a capital, placed upon a retort, in which water was boiled for a long time.

time. The vapour continually penetrating the osseous matter, gradually carried away from the gelatinous matter, and left the phosphate of lime more or less pure; so that the hartshorn became white and friable. This tedious and fastidious practice has been laid aside upwards of thirty years; at present they content themselves with calcining the hartshorn to whiteness, thus burning all the animal matter and insulating its calcareous phosphate. Pottery ovens are generally employed for performing this calcination, the intense heat which exists in these furnaces, produces an incipient vitrification of the earthy phosphate, and we frequently see the hartshorn thus treated in the pharmaceutical laboratories, sensibly approximating to the state of porcelain. The phenomenon, joined with all the preceding and that of the softening which the hartshorn experiences, when it is immersed in acid, proves that this matter is perfectly of the same nature with the bones, and differs from them only by its larger proportion of gelatinous matter.



C. Of Horn.

10. What is particularly called horn, in the arts, belongs to a substance which differs sensibly from the bones, and from hartshorn. These are plates of various thickness, semi-transparent

transparent, proceeding from the hollow and conical horns of the bullock. The hoofs of a great number of the mammalia; the horns of the antelope, the goat, the ram; the claws of the cloven-footed or digitated animals, the prickles of the porcupine and hedge-hog, the beard of the whale, and even the hairs, especially those which are rigid and hard, such as the hair of the head, and silk, are all of the same texture and chemical nature with horn. What I have said above, art 10. ord. 3, concerning the corneous texture in general, is applicable to what concerns horn properly so called; I shall here add only a word respecting what concerns the latter in particular.

11. The horn of the bullock, combining all the properties of the corneous texture already described upon a former occasion, and being composed of coloured gelatin, united with a small quantity of phosphate of lime, is susceptible of being fused by a mild fire, yielding much water, ammonia and oil in its analysis, swelling, and leaving a voluminous coal, exhaling a strong and fetid colour when burned, melting to a considerable degree in water, dissolving in the acids, and affording Prussic acid when strongly heated with fixed alkalies. These very well characterized properties, place the different uses which are made of horn, in a clear point of view. It is softened, extended, turned, moulded, rolled, it is folded by its edges, it is made to receive impressions, it is melted after

having been pulverised, in order to form vessels which assume the form of the moulds, into which it has been introduced ; it serves for the preparation of glue, and the extraction of several pharmaceutical products ; it is employed in the fabrication of Prussian blue, &c.

D. Of Wool.

12. WOOL, a kind of long, soft, curly hair, which covers the skin of several of the ruminating mammiferous animals, but which is particularly cut or thorn from that of the sheep, is in such universal use, that we should think it must be one of those animal substances, most accurately known ; however, it is only within a few years, that chemists have occupied themselves with examining it. Formerly, they contented themselves with considering it as diffusing a disagreeable smell, when it was burned, and as yielding much oil and carbonate of ammonia, by distillation. It had been remarked in common life, that it did not inflame without great difficulty, and that it exhaled a very fetid thick smoke, instead of taking a bright flame. Finally, it was known that the caustic alkalies easily corroded it, and that it quickly received, and forcibly retained the colouring matters that were imprinted upon it, so that it deserved the first rank amongst the substances to be dyed. The extremely nume-

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rous uses, to which it has been appropriated in a number of arts from time immemorial, had brought all its useful properties to light ; but chemistry had considered it only under its most general relation with all the animal matters, without ascertaining any thing specific, in it.

13. Citizen Berthollet began to occupy himself particularly with it in 1784, and 1785. He has shown that the caustic alkaline leys dissolve it entirely, and that the acids precipitate it from this solution ; in this combination, he has sought the mode of action which the alkalis exert upon animal substances, and he has particularly availed himself of it, for explaining the very remarkable energy which exists between these two matters. In this manner, he has especially accounted for the action of the lapis causticus, upon the bodies of animals. He has moreover shown, that the coal of wool was difficult to be burned, like that of all the other animal compounds ; that wool, treated by the nitric acid, afforded azotic gas, and oxalic acid, with a fatty matter.

Citizen Chaptal, applying this solution of wool in the alkalis, to the processes of the manufacture of cloth, has represented it as a soap of great utility, for these manufactures, and very well adapted for being substituted instead of that which is fabricated with vegetable oil. Wool has, moreover, been considered as a very bad conductor of caloric ; and upon this principle

ciple it has been explained, how, by retaining that which exhales from our bodies, it forms the warmest clothing, the best adapted for moderating the severity of the winters.

14. To these first facts, the immediate result of the views opened by the progress of modern chemistry, I must add the additional observations, which I have made on the nature of wool. The complete inactivity of water upon it, even when kept for a long time boiling in contact with it; the kind of unalterability which it enjoys, when it is kept in a dry and airy situation; the fusion which it experiences when it is heated; the large quantity of thick oil which it furnishes in distillation; the light action which the acids exert upon it; the lively impression which it receives from the alkalies; the considerable proportion of fatty matter which it yields, when it is treated with the nitric acid; the strong adhesion which it contracts with the colouring matters, have led me to consider it as a highly hydrogenated, semi-oleaginous matter; the exudation which impregnates it upon the body of the sheep, and from which it is freed only by saponaceous, or somewhat alkaline washings, is also a proof of it. In all cases, in which art succeeds in separating the azote from it, it is quickly reduced to the oily state. Thus, when the nitric acid turns it yellow, and disengages this principle from it, in the form of gas, a great quantity of fat oil swims at its surface, whilst the rest of the substance

passes into the state of carbonic acid. Thus, when it is treated with the fixed caustic alkalies, in concentrated leys, and especially with the aid of heat, there is disengaged from it, ammonia formed by the union of its azote, with a small quantity of hidrogen, and what remains united with the alkalies, is an oily body, constituting with them a saponaceous compound.

15. These opinions, drawn from the latest discoveries of the science, explain all the phenomena, and all the properties which wool presents, in the frequent and advantageous uses, to which it is constantly applied. The warmth which it affords, as clothing or covering, its impenetrability by water, its fine colouration, the durability and solidity of its dyes, its destruction by the alkalies, the facility with which grease, and oils penetrate it, the extension of the spots which are formed upon it, even the use which it has, and the functions which it performs upon the bodies of those animals, which are covered with it, and from which we take it in order to clothe ourselves; the adherent and fetid oil, the exudation with which it is impregnated upon the bodies of sheep; the manner in which it defends them against the rain and the water, which are so hurtful to them: its slow combustion; the yellowness and loss of tenacity that are produced in it by long exposure to the air, by gradually absorbing its oxygen, and losing a part of its
hidrogen;

hydrogen: in a word, all that appertains to its characters, its formation, its use, its various properties, its destruction, becomes clear and easily conceivable by the distinct determination of its nature, and of its composition.

E. Of Musk.

16. Musk, a substance pretty generally known by its strong smell, and its great use in perfumes, is a sort of resin. or extracto-resinous matter, that comes from a species of ruminating mammiferous animal, named by Linnaeus, *moschus moschiferus*, and *chevrotin* in the French nomenclature of natural history. This animal, shaped like the roe buck, having long canine teeth projecting from the mouth in the upper jaw, and a brown fur, with whitish, or fawn-colored spots, has a bag situated towards the navel, in which the musk is inclosed. It is a native of Tibet and Great Tartary: it is hunted for the sake of obtaining its perfume, which is sold with the bag which contains it. This matter is very rarely met with pure, and without addition or adulteration in commerce. As its smell is extremely strong, and as it is sufficient that there remain a small quantity of the matter of the musk for it to be very marked, resins mixed with different kinds of grease are added to it, on which account it is very difficult to ascertain

ascertain its real characters or chemical properties.

17. Puré musk is in dry grumous clots, greasy to the touch, of a brown colour, of a bitter and somewhat acrid taste, of a very strong smell, much resembling that of fragments of dried coagulated blood. That of Thibet is preferred to the musk which is sometimes collected in Russia and Siberia; it is also much dearer. Cartheuser says, that this concrete body is composed of very attenuated, moveable, oily, volatile and odorous particles, attached in some degree to a fixed gummo-resinous substance. The singular subtilty of this odorous matter, is known from several physical experiments. A single decigramme of musk, diffuses a strong and tenacious smell, through a large space, during several years, and can impregnate strongly five hectogrammes, or two thousand times its weight of an inodorous powder. Water and alcohol are equally flavoured by this odorous body. Though the whole of the musk is inflammable, and seems to be of a resinous nature, it appears that the gummy or extractive matter is superabundant in it, since Neuman extracted nearly a third of it by water, and only a sixtieth part by alcohol; it appears also, that musk contains ammonia, or is very much disposed to furnish it, for when it is treated with pot-ash, a very sensible vapour exhales from it.

18. Though the analysis of musk is far from accurate, yet it is evident from the facts al-

It is believed that this matter is a resinous substance, having a very volatile, and very inflammable nature, mixed with an extractive substance, and a certain quantity of saline matter. The fact is sufficient to account for its medicinal properties, its exalted quality, its heating and pungent odoration. It is ranked among the most antispasmodic, cordial, heating and stimulant. It is frequently given, either alone, or mixed with various substances, possessing the same kind of properties. It is sometimes distilled, and used as a alcohol. Its great use is in the composition of perfumes: it is mixed with musk, civet, and many other odorous matters, and is an ingredient in balsamic, unguentuous, and other such pulverulent compositions, and is much varied. It is one of the most useful ingredients in the perfumery art.

ESSENCE OF TORTOISE.

This is a substance very analogous to musk, which is extracted from two small species of marine animals, or quadrupeds, which bear the denomination the genus of which is called *Testudo*. These animals, bordering upon the fish and birds, are characterized by a long head, and the latter, four or five inches in length, and a rough tongue, semi-rigid, and a long thick short intestines, a small excrement, and especially a bag under the anus, which contains the unguentaceous matter,
called

lled *civet*. Of these two animals, the one is the civet, properly called *viverra civeta*, having a grey fur, spotted with brown, a tail of an uniform colour, and being a native of Africa: the other, which inhabits Arabia and the Indies, has an ash-coloured body, streaked with black, and a tail marked with rings of these two colours. However, the civet proceeding from the latter species, is preferred to that of the former.

20. Well chosen civet is a thick substance, like an ointment, of a pale yellow colour, of the consistence of honey or butter, of a somewhat acrid taste, and of a very aromatic odour; it is agreeable however, than that of musk, though sensibly analogous to it. It is said, that this humour distends the vesicles situated near the anus, irritating the animal, which rubs itself against trees and stones, and thus leaves some upon them, which is carefully separated; but it is more probable that it is collected from the bags themselves, with a spoon, after the animal has been kept inclosed, and after it has been tamed to a certain degree. It is to be remarked, that this humour, when recent, is whitish, and that when it is kept, it grows yellow and brown at the end of some time. In comparing civet with musk, both with respect to its properties and its nature, the authors on materia medica, and natural history, have remarked, that the first excites more disgust, and even nausea: besides its use, which has long been
been

been laid aside in medicine, is much less frequent in perfumery, than that of musk. This proceeds in a great measure from the scarcity of this odorous substance, and the excessive price which it bears.

G. Of Castoreum.

21. CASTOREUM is an odorous, extracto-resinous animal matter, analogous to musk and civet. It is found in two membranous bags, situated in the groins of the castor, a species of gnawing mammiferous animal, with elongated incisors, without canine teeth, and well characterized by its flat tail, covered with scales, after the manner of fishes. This animal, which inhabits the banks of great solitary rivers in Poland, Russia, Siberia, Canada, New England, and which formerly existed in France, upon the borders of the Rhone, and in Germany upon those of the Rhine, has been especially mentioned, on account of the industry with which it constructs a kind of buildings of several stories, above the water, with double openings for labouring in society with its species, and for its winter-magazines: their construction is with stakes and mortar.

22. Castoreum, recently extracted from the animal, has the consistence of honey, an acrid, bitter, and nauseous taste, and a strong smell, which it loses by desiccation. It becomes
resinous

inous by exposure to the air. When distilled with water, it furnishes volatile oil, and the water that is vaporized, carries along with it almost all its smell, with the oil which it solves. Alcohol, distilled instead of water, hardly acquires any smell, which proves the little volatility and tenuity of its odorous oil. When both of these liquids are successively employed as solvents, the first takes up a sort of grey coloured and odorous resin, the second, a gelatinous animal mucilage: when the aqueous solution, which becomes turbid, and coated with oil, by cooling, is slowly evaporated, saline crystals are obtained from it. The alcoholic solution gives a red, brown, and exsiccated-resinous residue; ether furnishes one more inous, and more inflammable. When either of these two last-mentioned solutions is mixed with water, a precipitate is formed, which, if it collects together, assumes a soft unctuous assistance, without becoming brittle by desiccation, which is liquefied by heat, and which yields a volatile and odorous oil by distillation. This oily, concrescible matter, greatly resembles that which exists in the bile, when it is separated by the acids. It is almost useless to observe, that the entire castoreum gives, by distillation in the retort, the same products as all animal substances.

23. Though the analysis of this matter is very far from having the accuracy that were to be wished, and though we can hardly hope to arrive

arrive at this accuracy, on account of the uncertainty which almost always exists respecting the purity of the castoreum, and of the mixture of resins, gum-resins, and fats, which are added to, or substituted for it, in order to adulterate it; what Neumann, Cartheuser, Cizens Thouvenel and Bouillon La Grange have done respecting the castoreum, authorizes to consider this matter as a mixture of a resin, a sort of adipocirous body, a volatile oil, extractive colouring matter, a gelatinous substance, and a salt. We must distinguish from it, the more greasy and oily juice which is found in the two small accessory bags, that are placed on the outside of the two large bags filled with the true castoreum: there is reason to believe, that the gelatin which is extracted from this by boiling, proceeds from the membranous laminæ, which, form the parenchymatous and follicular texture of the sides of these bags.

24. Castoreum is employed only in medicine. Though the disagreeable taste, the disgusting smell, and the nauseous property of this substance, frequently render its introduction, and first retention in the stomach, difficult; physicians have discovered very important and very useful virtues in this medicine. It is eminently antispasmodic; it is very useful in flatulent, hysteric, hypochondriacal affections; it is also found to have a stimulant power. It is successfully combined with opium, which diminishes

diminishes its irritating property. The experiments of Citizen Thouvenel, show, that it may be administered in much stronger doses, than had been done before him. Less energetic than musk, it is preferable to it in a great number of cases. It is rarely given alone, and in the dry form: most frequently it is prescribed in its solutions in alcohol, and ether which are called tincture of castoreum. It is an ingredient, in a great number of officinal preparations.

H. Of *Ambergrease*.

25. *Ambergrease* is a concrete, oily, and very odorous substance, of a soft and tenacious consistence, like wax, susceptible of being softened by the heat of the fingers, of a grey colour, sometimes reddish or brownish, marked with yellow or black spots, the smell of which becomes much stronger, and more pleasant, when it is heated or rubbed. It is in irregular masses of very various forms, most frequently roundish, composed of different layers of various thickness, frequently united and agglutinated together in such a manner, as to have considerable bulk. Pieces are met with that weigh a hundred myriagrammes. *Ambergrease* has manifestly been liquid, since different marine productions are found immersed, and enveloped in it. It is seen most frequently floating upon the sea water,

near the Moluccas, Madagascar, Sumatra, upon the coasts of Coromandel, of Brazil, upon those of Africa, of China, and of Japan. When it is broken, it is seen to be formed of species of scales, which detach themselves. It is insipid ; when it is very pure, it fuses without presenting bubbles or scum, on being heated in a silver spoon, over the flame of a taper : it swims upon water ; it does not adhere to the needles of red-hot iron, with which it is punctured, and which pass through it by melting it. That which does not possess those properties, is not pure, and frequently contains extraneous resinous bodies, with which it had been mixed.

26. Naturalists, in comparing the different species of ambergrease with each other, have distinguished several varieties of this substance. Wallerius has discovered and characterized the six following :

a. Ambergrease spotted with yellow.

b. Ambergrease spotted with black.

These two first varieties are the most valuable, and most in request.

c. White amber of a single colour.

d. Yellow amber of a single colour.

e. Brown amber of a single colour.

f. Black amber of a single colour.

However, all these varieties proceed from the admixture of some extraneous substances. They might be greatly multiplied, if regard were had to the different foreign substances which are found inclosed in the ambergrease;

but

ut it is of no utility to make such distinctions, indicate nothing regular and constant in the substance which they represent.

27. Mineralogists and naturalists in general, have held many different opinions respecting the origin of ambergrease. Most of them have regarded it as a bitumen, as a mineral oil, as a petroleum that has flowed from the rocks, and been thickened by the rays of the sun, and the long contact of the salt water.

Several have thought it proceeded from the excrements of birds that feed upon odoriferous herbs.

Some have considered it as a scum discharged by the sea-calves; others as crocodile's excrements.

Pomet and Lemery thought it was formed by mixture of wax and of honey, baked by the sun, and changed by the water of the sea. Forney, of the academy of Berlin, who adopted this opinion, endeavoured to confirm it by positive experiment. He put a mixture of wax and honey to digest in the sun, and he says, that he obtained from it, a product of a very agreeable smell, and very analogous to that of amber.

Some English authors have considered ambergrease as an animal juice, deposited in bags situated near the origin of the genital organ of the bale whale; some also have thought that this juice was formed in the urinary bladder of this cetaceous animal.

Finally, Dr. Swediaur, after an attentive inspection of a great many specimens of amber, and according to the reports of several travellers and whale-fishers, who have assured him, that this product was frequently found amongst the excrements of the *physeter macrocephalus* or in the intestines of this animal, has proved, that the amber is formed in the alimentary canal of this cetaceous fish, which also furnishes this spermaceti. His opinion is founded, 1st, Upon the circumstance, that the fishermen often find amber in this fish; 2d, Because this juice is common in the seas which it inhabits; 3d, Because the cuttle-fish, *sepia octopus*, upon which it feeds, inhabits the same places; 4th, Because the black spots which are so frequently found in the amber, are only the beaks of this animal, the most common of the bodies that are found inclosed in this concretion; 5th, Finally, because the excrements of several of the mammalia, especially those of the bullock, the hog, &c. frequently exhale a smell analogous to that of ambergrease, when they are kept for some time. Thus, the result of the researches of Dr. Swediaur, agrees with the opinion of the Japanese, and of Kämpfer, who regard amber as the excrement of the whale.

28. Ambergrease, whilst it corresponds with a resinous matter, affords also some products analogous to those of the bitumens, on which account Geoffroy, Neumann, Grim, and

and Brow have ranked it among these bodies ; they say they have actually extracted from it, an acid liquor, a concrete acid salt, oil, and a oily residuum : but these products are not sufficient to decide the nature of a bituminous body, for they belong to many other substances besides the bitumens. Ambergrease is in great part soluble in alcohol, and in ether. This solution is precipitated by water, like that of the resins ; this property is different from the almost absolute insolubility of the bitumens in these liquids. Hitherto, neither the action of the acids, nor that of the alkalies upon ambergrease, has been examined ; and, in general, it is one of the substances with which the chemists have hitherto least occupied themselves, though it would be of considerable utility if they would undertake an exact analysis of it. It would be useful to know, what species of acid is obtained from its distillation, if it does not contain a concrete oily matter, analogous to that which exists in the bile, &c.

29. Ambergrease is considered in medicine, as a stomachic cordial, and antispasmodic remedy. Most astonishing effects are mentioned to have been produced by this substance, in the most dreadful convulsive diseases, such as the tetanus, and hydrophobia. It is especially reckoned amongst the most powerful aphrodisiacs. It is given in substance, or in the alcoholic tincture. Some individuals are so sensible to its effect, that they cannot support its

action, nor even its smell. It is much employed in perfumes, of which it is one of the most frequent, and most abundant bases. It is almost always mixed with musk, which it has the property of attenuating and softening, at the same time rendering its smell more pleasant and agreeable than it naturally is. It is known that very little of it is required for perfuming large surfaces, and for a very long time, and that it is one of the substances which philosophers have used, for proving the divisibility of matter, though in this respect, it is greatly inferior to musk.

I. Of *Spermaceti*.

30. The name of spermaceti, (Fr. *Blanc de baleine*) is given to a concrete, white, brilliant, and oily substance, which is extracted from the head of the fish, named by Linnæus, *Physalus macrocephalus*, the same which furnishes the ambergrease. This cetaceous fish, which is well characterized by its large head, its straight and pointed teeth, a tuberosity in place of the dorsal fin, its length of twenty metres, of which the head alone amounts to half, has the upper part of the cranium covered with a cartilage instead of bone, and contains, in cavities separate from that of the brain, which is extremely small, the particular substance of which I speak. It is therefore, neither the sperm of the

the whale, nor the cérebral medullary matter, as many authors had advanced. It is an oil which furrounds the pulp of the brain of this animal, which particularly inhabits the seas of warm climates.

31. When the spérmaceti has been extracted from the head of the fish, it is found to be mixed with a certain quantity of oil, which is separated from it, by means of the press. It seems that the same matter is held in solution in the oily fat of all the cetœ in general; for the oil which is obtained from these animals, and which the whale-fishers introduce into commerce, under the general name of fish-oil, constantly deposits in the vessels in which it is kept, a more or less considerable quantity of this concrete matter; and in this manner it is extracted from it, in the places in which these oils are purified, by merely remaining in reservoirs. It also appears, that this matter is one of the most general products of the bodies of the marine animals, since the oil which is extracted from the liver, and from several other parts of some species of fish, equally gives, by mere repose, the same substance, which is separated from it by a real crystallization. We shall soon see that this production is in fact one of the most constant phenomena of animal matters in general.

32. Spérmaceti, purified by repeated fusion, crystallization, and pressure, is crystallized in white, brilliant, silver-like plates; it has a peculiar

culiar faint smell, which ought not to be confounded with its rancidity. It easily crushes between the fingers, into a white, lamellated greasy, and unctuous powder, which is brilliant, like the lamellæ of stearites. It fuses more quickly, and at a lower temperature than wax, but a little less easily than common fat. When it is thrown upon ignited coals, it inflames, and burns in an uniform manner, without crackling, and without emitting a bad smell; its flame is very clear and bright: accordingly candles are made of it, which are preferred to all others, in the countries where this matter is common. Melted spermacet does not stain the stuffs, upon which it drops: it is easily detached from them by mere friction, and separates in the state of powder.

33. When spermaceti is distilled in the retort it is not decomposed without much difficulty; when it is fused and boiling, it passes almost entire, and without alteration, into the recipient; it yields neither water nor sebacic acid; its products have not the strong smell of those from fats. However, the nature of a part of this fatty substance, becomes changed, as it is in the state of liquid oil; and if it be distilled several times, successively, we at length obtain it completely oily, liquid, and inconcrescible. Notwithstanding the apparent alteration which it undergoes in these repeated distillations, the spermaceti does not acquire more volatility than it had before; and according to Citizen

Thouvenel,

Thouvenel, the same degree of heat is required for volatilizing it, as in the first operation. The oil also into which it is converted, has not the lively and penetrating smell of those which are extracted from the other animal matters, treated in the same manner. The distillation of spermaceti with boiling water, according to the same chemist, presents nothing remarkable; the water of this kind of decoction is a little curdled; filtered and evaporated; it leaves a small quantity of mucous and bitter matter as a residuum. Spermaceti subjected to ebullition in water, becomes more solid, and more soluble in alcohol, than it is in its natural state.

34. Exposed to the air, spermaceti becomes yellow, and sensibly rancid; though its rancidity is more slow, than that of the fats, properly so called, and though its smell is then less sensible than in the latter, on account of that which it has in its fresh state; this phenomenon is, however, sufficiently discoverable in it, to have induced physicians to observe, that its use ought then to be rejected. It combines with phosphorus and sulphur, by fusion; it does not act upon the metallic substances.

The nitric and muriatic acids, have no action upon it. The concentrated sulphuric acid dissolves it, and modifies its colour, and water separates it from this solution, as it precipitates camphor from the nitric acid; the sulphuric acid discolours and bleaches it; the oxygenated muriatic acid turns it yellow, and
does

disgust which this medicine inspires, might have had an influence upon the production of the effect which he indicates. Several persons also, to whom he administered it in a strong dose, were attacked with weight at the stomach, and vomiting, though he took the precaution of mixing the spermaceti melted in oil, with yolk of egg and syrup, thus reducing it to the state of a kind of cream. He never found this body again amongst the excrements, which proves that it was absorbed by the lacteals, and actually digested.

57. I must remark, with respect to spermaceti, that having found an analogous substance in the biliary calculi; in the bilious excrements of several patients; in the parenchyma of the liver, dried for a long time in the air; in muscles putrefied in the midst of water, and humid earth; in brain that had been kept immersed in alcohol; and in several other circumstances, which I have mentioned elsewhere, I concluded that this matter, much more frequent, and much more abundant in the animal compounds that had been foreseen, or even suspected, was one of the most constant, and even the most common products of the alteration of these compounds; that it consequently deserved to fix the attention of anatomists, physicians, physiologists, and chemists; that it was necessary to characterize it, by a name proper for distinguishing it from all other analogous substances. It is with this intention, that I have proposed to

name it *adipocire*, as it seems to hold an intermediate place between wax and fat, without being either the one or the other. Its formation and separation, are of considerable consequence in the animal economy, whether we view it as a natural production in the cetœ, or as the product of a morbid or septic alteration in man, and the other animals.

K. *Of the Bezoars.*

38 THE bezoars are calculous concretions, found in the intestines of several quadrupeds. There is scarcely any of them that is exempt from this kind of malady. Horses are very subject to them, and their intestinal concretions are frequently of extraordinary bulk; several of them are sometimes found, which have been worn by friction, and which present triangular faces. They are met with even in the wildest animals, and enormous bezoars of the elephant, the rhinoceros, and the hippopotamus, are kept in valuable cabinets. Formerly, the bezoars of the porcupine were much valued: we see some of them suspended in spheres of silver wire, amongst the collections of *materia medica*.

39. Though the oriental and occidental bezoars, have been distinguished from each other, and though a much greater value has been attached to the first than to the second; though
finally,

finally, even this distinction has proved, that several species of bezoars were admitted; the most frequent, and the most employed, were those that were found in the intestines of a species of goat, which inhabits the mountains of Asia. This animal *capra ægagrus* of Linnæus, which appears to be the principal stock of the domestic goat, and of that of Angora, is well characterized by its rough hair, its short black tail, and its large knotty horns. But I must apprise the reader, that notwithstanding the opinion of all the authors of *materia medica*, who have especially recommended this bezoar, several species of bezoar have almost always been employed indiscriminately, at the period when the art attributed great virtues to this animal concretion.

40. We have no exact analysis of the oriental bezoars; but if we may trust to an analogy which every thing announces to be correct, it appears, that these intestinal concretions, all of which have for their base or their nucleus, some vegetable matters that have been detained in the intestines, are constantly formed of ammoniaco-magnesian phosphate, more or less pure, or mixed with extract and colouring vegetable matter. It is this last foreign matter, which gives to the bezoars their varied green colour, their spots of different casts, their strong or aromatic odour when they are rubbed, when they are pulverized, or when they are heated. Those of the bezoars, especially of the
occidental

occidental kind, which I have found to be formed of phosphate of lime, appear to have belonged to the calculi of the bladder. Daubenton has remarked, that the brown or gold-coloured covering, which is found upon the molares of the ruminant animals, is of the same nature with the bezoars that are formed in their intestines; and it may be believed that the matter which constitutes these depositions, is dissolved in the digestive juices.

41. We ought not to confound with the natural bezoars, those artificial ones, which are fabricated by mixing earths with a small quantity of glue, and impregnating them with ambergrease, musk, or civet. The exaggerated ideas which formerly prevailed respecting the virtues of these concretions, had induced some druggist to imitate them by art. They are easily distinguished from the true bezoars, by their not being formed of regular concentric strata, as these are; by their strata not containing the lamellated, or alveolated, or spathose crystals, which constitute the strata of the natural bezoars; and finally, by their chemical nature being entirely different.

ARTICLE XXIX.

Of some Matters peculiar to Birds.

1. **THOUGH** the birds form a very numerous class of animals, they furnish but few peculiar matters to the arts and to medicine, if we except the very numerous species, which serve for food in the different places which they inhabit or pass through, and the ornaments which almost all nations make of their feathers. Under these two relations, they present only the two following remarks that are of importance for chemical consideration. The difference of the taste and smell of their flesh, according to the parts of the globe which they inhabit, and the kind of nourishment which they take; and the flavour of the muscles of their wings, and the upper part of the trunk, compared with that of the muscles of the legs: the second must relate to the beauty and the variety of their plumage.

2. It is known, that the birds of prey are in general hard, and coriaceous, that the aquatic birds are fat and oily, that the gallinaceous are the mildest and most nourishing; that in the class of animals, as in that of the mammalia, two kinds of flesh are distinguished; the one
black,

black, very fapid, a little acrid, and perfumed, which exists principally in those birds that have the most rapid flight, and which frequently change their place; the other white, mild, and insipid, which is generally met with in the gallinaceous tribe; that this difference depends also upon that of the aliments, which the birds use; those with black flesh, called black game, living upon insects or aromatic seeds; those with white flesh, living upon mild and cereal seeds; that the desired flavour and quality may be communicated to their flesh, by selected aliments; that an influence is produced upon the abundance of fat, and even upon the consistence and taste of the viscera, especially of the liver, by the kind of nourishment which is given them; finally, that there is a very remarkable difference in many birds, between the muscles of the legs, and those of the wings; the first are of a red or brown colour, and of a particular taste, those of the wings are white, and yield little nourishment. It appears, that the respiratory organ, extended into the bones of the wings, and the passage of the air into the superior parts, are the true causes of this difference between the muscles of the upper, and those of the lower part of these animals.

3. The feathers coloured with the richest hues, and forming one of the most beautiful ornaments of animated nature, are, to the chemist and naturalist, among problems, the most difficult to be understood. It is not only in
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the origin of these colours, so multiplied and diversified the cause of their variation, existing even in the continuity of the same feathers, that the difficulty of this problem consists. It exists with still greater force in the difference of the colours, which follows that of the sexes, and especially in that which depends upon the age of the birds, the regions which they inhabit, and even the seasons which cause them to vary. How many errors have not arisen in the distinction of the species, from these variations in the plumage, dependent upon sex, age, climate, and season? Who shall tell what the matter is, which diffuses the rubies, the emeralds, the topazes, and the sapphires, or that which shines with the lustre of these precious stones, and of streaks of gold, upon the covering of birds? At what period will chemistry be sufficiently advanced, to be able to determine with precision, the colouring matter, and its formation.

4. Hoping that these important questions may be successfully discussed in more happy times, let us at present treat upon such of the matters formed by the birds, as are the most generally employed, and consequently deserve more particularly to fix our attention. We shall not rank amongst these matters, either what are called *halcyon-nests*, a dry and gelatinous matter, which serves for the construction of the nest of a kind of swallow, and which they use as an aliment in the Levant, after having boiled it in water, and seasoned it with different

different aromatic substances, or the duck's beaks which are employed in China for the preparation of a glue destined for covering paintings upon paper, or the *fats* of different birds to which particular virtues were attributed, or the *down of the swan*, considered as as specific in cancerous pains and tumours, or the *feathers of the partridge*, &c. which were preferred for burning under the nostrils of nervous and hysteric women, &c I reckon only four substances which deserve to occupy us in particular, either on account of some very remarkable property, or of the great importance of their uses; these are the eggs, the feathers, the dung, and the membrane of the stomach.

A. Of Eggs.

5. THOUGH the eggs of all birds have a very strong resemblance with each other in their general structure and composition; though they may all be employed for analogous uses, the eggs of the hen are especially the subject of consideration as it is from this bird, which is easy to be reared, fed, and multiplied, that the eggs are most frequently taken for all the uses to which they are applied. The egg of the hen is composed of white, yolk, ligaments, which are called *glaire*, of the chick, of a thin interior membrane, and of a solid shell placed outwardly and serving as a cover to all the parts of which the egg is constituted.

6. The white of the egg, *albumen* liquid, viscous and gluey matter, which rounds the yolk, and forms two very layers about it. Though the viscosity of the liquid proceeds from its peculiar nature, owing to a light filamentous and vascular system, which traverses it in all parts, and it in a very transparent kind of vesicular white has an insipid taste; it thickens, becomes white, opaque and solid by boiling; it turns into a yellow, transparent, brittle, aciniform matter by a gentle, long continued heat. This coagulation, this solidification by fire, constitute the most marked characteristic of the white of the egg, and it is on account of its existence in several liquid animal matters as the serum of the blood, &c. that they have been called albuminous liquors. The white of the egg when fresh turns the blue vegetable green, it hardens in hot and dry air into a transparent stratum that is frequently employed as a varnish upon pictures; by exposure to air, it absorbs a greater quantity of water than it contained, and acquires the disposition to be more speedily and more strongly hardened by fire; it dissolves easily in water, with the exception of some flakes which swim upon the surface, dissolving, in case the white of egg is oxygenated. The acids coagulate this, the alkalies re-dissolve it in part; the mineral solutions render it turbid, and precipitate it as well as lime-water. The oxides of the

cause it to coagulate. We find in it, by an exact analysis, muriate of soda, phosphate of lime, and very a small portion of sulphur, which is disengaged from it during coction in the state of fulphurated hidrogen gas.

7. The yolk of the egg, *vitellus ovi*, is also a species of albuminous matter, soluble in cold water, coagulable by heat and by the acids, which besides contains a colouring substance hitherto little known, and which perhaps may be iron, and a certain quantity of mild oil which is seen to exude from the yolk when it is hardened and heated, and which is extracted by the prefs: this oil of egg is prepared in pharmacy, and employed in medicine as a topical, emollient, and relaxant remedy. Its presence in the yolk establishes a remarkable analogy between the seeds of vegetables and eggs. It is the cause of the emulsive form which the yolk of egg assumes when it is beat up with water, or the animal emulsion called (*lait de poule.*)

8. The ligaments or *chalazæ*, which are called glaire, and which suspend the interior parts of the egg, are a kind of albuminous cord more solid than the white, nearer at least to the concrete state, and consequently believed to be more oxygenated. The chick is placed upon the yolk, and always presents itself opposite to the hole which is made in the shell, in whatever manner we may place the egg, since it is

situated upon the thinnest part of the yolk traversed by the ligament, round which the yolk turns as upon an axis; it contains the rudiment of the body of the bird, which requires only to receive movement by incubation, and which is developed by the effect of this movement; the chemical nature of the chick is not known, nor has it even been possible to analyse it in particular.

9. The interior membrane of the egg, which envelops the white and the yolk, and which is glued to the interior surface of the shell, is, like all the other animal membranes, a gelatinous matter which melts in boiling water. Notwithstanding its dense and close texture, it manifestly suffers elastic fluids, and vapours to transpire from the interior of the egg outwards, and from without into the interior of the egg; it is upon this principle that we may explain the loss of weight which the egg experiences when it is kept in dry air, and the action which acrid or deleterious vapours exert upon the chicken inclosed in it. Anatomists have injected this membrane and proved its communications with the texture of the white. The shell, formed of small granulated bodies, placed by the side of each other, entirely perforated with small holes and ducts, which are discovered in it by the art of injection or the transudation of coloured liquids, is not solely composed of carbonate of lime mixed with gelatinous substance as had long been believed; but it also contains a portion of phosphate of lime, which even the weak acids dissolve

dissolve with ease, as it is disseminated in a large quantity of calcareous carbonate. This solid shell is deposited after the white in the canal of the oviduct upon the yolk that has descended from the ovarium, during the time that this yolk remains in the canal, (see the Article concerning the Excrements.)

B. Of the Feathers.

10. I HAVE spoken, in the first number of this article, concerning the beauty and variety of colour of feathers. I shall here treat of their nature as applied to the principal uses for which they are destined. The feather is in general a round, horny, transparent tube, filled with a mucous marrow, terminated by a solid prismatic part, and provided in that part with plumes placed obliquely upon the two opposite sides. The difference which exists between the feathers, according to the situations in which they are placed, and the functions for which they are destined, depends chiefly upon the relative size of the cylindrical canal, and the solid part, and of the length and strength of the plumes. One sort, the smallest, are only like scales or integuments covering the body and defending the skin, the others, those of the wings or of the tail, are strong and long ducts, the sides of which are hard and solid, having the full and prismatic part drawn out to a great length and tapered, with broad
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and extensive plumes, which present a very large surface to the air or the water which they are destined to strike. These last-mentioned parts, the plumes, are themselves very much varied, elongated, flattened, close, separate, simple or ramified, straight or curled, according to the variety of functions which they are destined to fulfil.

11. The nature of the feathers singularly resembles that of horn in general; in the fire they melt, become brown, fume, exhale a strong oily and ammoniacal smell, they swell and at last inflame, leaving afterwards a brown or black light cinder, difficult to be calcined; a little saline, containing phosphate of lime, a little carbon and frequently phosphate of iron. Distilled in a retort, feathers afford a fetid water, a dense and almost concrete oil, carbonate, prussiate, and zoonate of ammonia, carbonated and sulphurated hydrogen gas. Boiling water softens and at last dissolves the corneous matter, and reduces it to the gelatinous state; the acids and the alkalies soften and dissolve also; many of the colouring matters attach themselves easily, and adhere strongly to the surface of the feather and especially of its plumes. It is known that an ingenious artist exists of dyeing feathers and giving them all possible tinges.

C. Of the Dung of Birds,

12. THE excrements of birds have a very distinct character, and properties very different from those of the excrements of man, and the mammiferous animals. Two matters very remarkable by their differences, are constantly distinguished in the dung of birds; the one, which frequently is the most abundant, is of a dark-green, or brown colour; the other white, and drier than the preceding. In general, the fetidity is not so strong in the excrements of birds, as in those of other animals. It is known also, that the urine which has no other out-let, passes off by the same emunctory, and that it is in very small quantity. Finally, there is frequently remarked on the outside of the excrements of birds, a glairy matter, more or less transparent, analogous to the white of egg, and which indeed appears to be only a superabundance of the albumen, that lines the superior part of the oviduct, which is carried along with the excrements.

13. The coloured part of the dung of birds, is an alimentary residue, like that which composes the greater portion of all the excrements; but the white part is of a quite different nature; we find in it by analysis, all the characters of a mixture of carbonate or phosphate of lime, and of albumen. It is therefore the same substance

stance which constitutes the shell of the egg, and it appears in fact, that having the same origin and being in the same place with it, it can only be considered as the superfluity of that which serves to form the concrete and solid covering of the eggs. It seems that this kind of evacuation corresponds with that of the phosphate of lime, which takes place by the urine in man, and in the deposition of the same salt, in the horns, the hair, and the hoofs of the mammiferous animals.

14. It is known in agriculture, and in the practice of some of the arts, especially in that of the tanner and the skinner, that pigeons' dung is a sort of acrid matter, which forms a hot and very active covering for the earth, and a very energetic agent for the softening and separating of the hairs. Citizen Vauquelin, in a first inquiry upon the dung of the pigeon, made in hopes of discovering the cause of its utility in the preparation of skins, has found that this excrement ferments with great promptitude and energy, and that it contains a pretty strong acid, which has appeared to him to be of a particular nature, different from that of all the known acids. I have already remarked, in a preceding article, that it is pretty frequent to find a character of acetous acidity in the human excrements; thus, the acescence may one day be reckoned amongst the properties, which belong to the residue of digestion.

D. Of

ies which they present, or even the dangers with which they threaten us, or the fears which they inspire. These are the tortoise, the lizard, the scink, the toad, the frog, and the viper: we shall say a few words concerning each of these species.

A. *Of the Tortoise.*

2. THOUGH most of the species of the tortoise may be ranked amongst the emollient and nutritive aliments or medicines; though some of them even afford dishes that are in high esteem, such as the eggs of the sea-tortoise: it is especially the fresh water or land-tortoise, called also the common or muddy turtle, *testudo lutaria*, which is the most generally employed, and the most useful. If it be not correct to consider it as a valuable remedy, and to attribute to it the antihæctic and antipulmonic property, on account of which it has been prescribed in broths by the French physicians; it is useful at least to know, that its flesh affords a mild and wholesome nutriment, that it nourishes easily and abundantly, that navigators find in it when on shore, an aliment very well adapted for removing the scorbutic affections, with which they are so frequently attacked; and that some nations make a very frequent use of it. This flesh is easily reduced
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into a jelly, by decoction in water; the broth soon grows four.

3. The covering of several kinds of tortoises, is one of the matters that are most frequently, and the most usefully employed in the arts, under the name of tortoise-shell. This shell is formed of hard, and somewhat flexible layers, more or less thick, closely applied to two osseous bucklers, attached to the spine and the ribs: that of the back is called *carapace*, and that of the belly, *plastron*. These laminae when detached, are sawed, cut, turned, polished, softened, curved, moulded, in a word, a multitude of very varied forms are given to them. The tortoise-shell has a great analogy with horn, its firmer texture, is susceptible of a finer polish; its red or brownish colour, frequently spotted and clouded, renders it more valuable for those utensils, in the fabrication of which it is employed. As it is susceptible of being softened by boiling water, its powder and chips are shaped into any forms that are desired by melting it in boiling water, and with the aid of moulds; figures, a kind of basso relievos, or engravings in intaglio are imprinted upon it; it is in this manner that boxes are fabricated of the fused shells.

B. *Of the Lizard.*

4. THE genus of lizard, which is characterized by a long body, four short legs, a long tail, thick at the base, and continuous with the body, comprehends the crocodile, which was formerly made use of in medicine; the guana, a large lizard of America, the flesh of which is excellent food; the cameleon, famous for the changes of the colour of its skin, of which fabulous accounts have been given; the salamander, whose glaucous humour has caused it to be considered as capable of extinguishing fire, and consequently of preserving its life in the midst of burning coals; finally, the grey and green lizard, commonly an inhabitant of our temperate climate, and the warm parts of Europe, and the scink which is found in Africa: these two last merit our particular consideration, and I have distinguished them under this point of view, in the class of reptiles.

5. The common, or grey lizard, which dwells between the stones of old walls, and lives upon insects, is remarkable for its slender form, and rapid pace. Its flesh is very good to eat; and were it larger, it would be as much esteemed as the guana of America. It has been extolled as a sort of specific in diseases of the skin, especially in herpetic eruptions, and even in cancers; it is administered broiled, as food. This specific
virtue

virtue has been especially attributed to the green lizard, remarkable for its brilliant colour, and more frequent, and larger in the hot countries of Europe, than in the temperate. Its flesh has a somewhat stronger, and sensibly aromatic taste. Unprejudiced physicians consider neither of them as any thing more, than a simple nutriment, which, when substituted for another, is capable of modifying for some time, the nature of the humours, and thus producing some changes in the individuals who use it.

C. *Of the Scink.*

6. THE scink, *lacerta scincus*, is a small lizard, of a silver-white colour, with a tail shorter than its body, and with very short legs, which inhabits the dry places of Africa. A considerable traffic was for a long time made with it into Europe, because it was formerly employed in medicine. It was exported, when dried in the sun, and become brittle. An alexiterial, and particularly a restorative virtue, was attributed to it. It was prepared in broths; it was administered even in powder; but as it was associated with several other aromatic, acrid, and hot matters, virtues were attributed to it, which belonged only to the medicines, with which it was prescribed. In fact, it is merely nutritious, like the common lizard.

D. *Of the Toad.*

7. THIS is another reptile that has been the subject of prejudices of every kind, and which, from ignorance, has been both an object of terror and a medicinal substance. The form, the disgusting colour of the toad, *rana bufo*, have caused it to be reckoned amongst the poisons. Its bile, its flaver, its urine, and its transpiration, have been dreaded. None of all these fears has any just foundation. It is equally erroneous to suppose, that it possesses the important medicinal properties that have been attributed to it; it is neither fit for expelling all kinds of poison out of the body, nor capable of restoring to persons, debilitated by long continued diseases, the vigour and strength that had been expected from its use. These virtues were thought to be communicated to it, or preserved in it, by leaving it to die exposed to the sun, after having suspended it by one of its hinder legs; by shaking, and whipping it with rods; it was preserved dry; its powder was employed in a multitude of alexiterial, alexipharmic, and cordial compositions; it was subject to distillation, the volatile salt that was obtained from it, was preserved, &c. More than forty years since, its pretended virtues have been considered fabulous, and its medicinal use ridiculous and futile.

E. *Of*

E. Of the Frog.

8. THE frog, *rana esculenta*, which affords a light, wholesome, and sufficiently agreeable aliment, was formerly also ranked amongst the medicinal substances. The glairy and gelatinous humour which envelopes its eggs, was particularly used under the name of spawn, *sperniola*; it was applied to painful or inflamed parts, in order to allay the heat and pain; the water obtained from it by distillation, was likewise employed. The whole frog, especially that which inhabits thickets, and which is known by the name of *rana arborea*, was considered as capable of allaying febrile heat, when held alive in the hand. It was also given in broth, to produce the same effect. This last use, that of forming a mild and refreshing broth, is the only truly rational one, to which it can be applied.

F. Of the Viper.

9. THE viper, a species of the genus *coluber*, called *coluber berus*, characterized by 146 ventral plates, 39 caudal pairs, a compressed, flat, triangular, scaly head, a grey skin, marked with two rows of brown spots, disposed in zig-zags upon the back, presents two kinds of con-

considerations, upon which chemistry may throw some light, and which consequently belong to her province. The first relates to the medicinal and economical use of the whole; the second comprehends what belongs to the venom of this serpent, to its nature, its effects, and the means of destroying them. I must take a hasty view of them, under each of these relations.

10. Formerly, such a number of virtues, and those so very important, were attributed to the viper, that there was not within the whole power of the art, a more important remedy, or one that was employed in a great number of diseases, with such unbounded confidence. Its flesh was an ingredient in the famous broths, which, besides their restorative properties, were supposed to act as specifics in diseases of the skin, and of the lungs, and especially in the chronic affections of the lymph, as well as in malignant fevers, in agues, and even in the plague, the itch, and the scurvy. Their depurating property, attributed to a volatile or aromatic part which was supposed to exist in them in large quantity, was extolled without reason, and without bounds.

The head of the viper dried, was thought to combat all poisons, and particularly that of the animal itself.

The liver and heart of this serpent, dried and pulverized, was supposed to possess a great activity, and the pompous name of animal bezoar, was given to them. The fat passed for a sudorific,

resolvent and anodyne, its gall for a detergent, and eminently adapted to the diseases of the eyes.

The volatile salt and the spirit, or the ammoniacal oily carbonate, and the water charged with this salt, that were obtained from it by distillation in the retort, were also prescribed.

All these grand qualities reduce themselves to the alimentary nature of its flesh, which is perhaps a little more irritating and active, when compared with that of the mammalia, and the birds.

11. The history of the poison of the viper, is of much greater importance, than that of the entire animal, considered as a medicine. The last is almost entirely hypothetical; the first, which is entirely experimental, has enlightened us, respecting a danger, which, not unfrequently menaces our own existence, or that of animals valuable to us. Fontana, after Redi, Charas, Mead, Nichols, and James, have made researches, which have given a great degree of accuracy to this history. The viper, like every other kind of poisonous serpent, has in its upper jaw, two large canine teeth, frequently surrounded at their base, with several other smaller teeth, bent backwards, and designed, either to bite together with them, or to supply their place when they fall out. These teeth, implanted in a wide alveola, and covered at their base with a membranous reticular texture, are
curved

curved towards the bottom, and very straight at their point, which is extremely sharp. Besides a blind triangular cavity, a kind of sinus, occupying as in all the teeth, the greater part of it, the venomous tooth is perforated by a conical channel which opens towards the bottom by a triangular hole in the reticular texture, and by an elliptical fissure under the point of the tooth. These two apertures, placed at the two extremities of this canal, are situated upon the connected part of the tooth; that from below, receives, by a membranous duct, the venomous humour which flows from a triangular tendinous vesicle, situated upon the lateral part of the upper jaw, at a certain distance from the tooth, and compressed by a very strong muscle; so that the poisonous humour is not contained in the texture which envelopes the base of the tooth, but conveyed by a duct which perforates the maxillary bone, and communicates immediately from the vesicle with the base of the dental duct: in biting, it issues from the mentioned duct, through the elliptical orifice which occupies its extremity, and with which the lower part of the point of the tooth is grooved.

12. It is well proved by the experiments of Fontana, that the yellow humour, proceeding from the maxillary vesicle, compressed by the effect of the bite, arriving immediately at the dental duct, without entering the reticular texture, and discharged by the elliptical orifice,

situated under the point of the tooth, is the true poison of the viper; that the saliva and the buccal humour are not venomous; that the bite without this discharge, whether on account of its being exhausted, or on account of the vesicle being taken away, or its duct tied, has nothing venomous or dangerous. The poison of the viper, is therefore attached to the nature of this humour, and its chemical examination has become an inquiry of the greatest importance. The physician above-mentioned, has neglected none of these researches; several thousands of these animals, which he procured very easily at Pisa, were sacrificed to his experiments, of which I shall here present the result in as precise a manner as I am able. The venom of the viper, is not a poison to its own species; it does not kill leeches, slugs, snails, asps, snakes; tortoises are not killed by it without much difficulty. It is neither acid nor alkaline; it contains no salts that crystallize by evaporation, and the streaks that divide it when it dries, have been erroneously considered to be saline crystals. It has no decided taste when applied to the tongue; it is neither acrid nor burning, like the humours of the bee, the wasp, and the scorpion; however, it is not insipid, but leaves for several hours a sensation on the tongue, similar to that caused by astringents. The animals, dogs especially, seem to relish pastry and bread impregnated with it. It excites no pain in the wounds,

nor inflammation in the organs upon which it is applied.

13. The venom of the viper is yellowish, somewhat viscous like a mucous liquor; on account of its unctuousity, it resembles an oily liquid in appearance; it is inodorous, thickens quickly in the air, and becomes similar to a transparent jelly; it then adheres strongly to the teeth, like pitch. It is not in any degree inflammable when exposed to the fire. When it has become dry by long exposure to the air, it still preserves its venomous property, and on this account we ought to be upon our guard in handling dried vipers' heads; however, ten or twelve months keeping seems capable of destroying its deleterious property. It dilutes itself in water, and dissolves in it when it is agitated; if we throw it into water at the moment when it has just been extracted from the vesicle, it immediately falls to the bottom after the manner of some heavy oils. It preserves for some time its colour, its viscosity, and its particular existence; hot water dissolves it after its desiccation; alcohol does not dissolve it; it is not coagulated by boiling water; the acids or the alkalies do not sensibly alter or dissolve it. The aqueous solution of the poison is precipitated by alcohol; it cracks in drying, after it has been precipitated, and in all the experiments, it shows so much analogy with gum, that Mr. Fontana calls it an animal gum.

14. Whilst

14. Whilst it was impossible for the science to determine *a priori*, or according to its known nature the manner in which the venom of the viper acts upon animals, it only remained to investigate, by the effects themselves upon the animal economy, in what this action consists; and this has been done by Mr. Fontana. This humour certainly does not act either by its acidity or its saline acrimony, as it possesses neither of these qualities. It resembles opium in its action; it diminishes and destroys the irritability of the muscles; it coagulates and blackens the blood, it excites putrefaction; it is in this manner that it kills animals. The part bitten by a viper is manifestly diseased, inflated, livid, sphacelous. When injected into the veins, the poison kills still more quickly; it acts more speedily upon the animals with hot than upon those with cold blood. The danger of the bite is so much the greater, and death so much the more certain and speedy, as the animal is less strong, and less heavy. Man and the large animals do not ordinarily die of the bite of a viper, and it is requisite that these serpents should be multiplied in proportion as the animal is heavier, in order to produce this effect. There exists, therefore, a relation between the bulk and the strength of the animal, and the active and deleterious property of the poison of the viper.

15. The venom conveyed, either by the tooth itself or by other means, into a superficial wound

wound of the skin, is not mortal. If the skin is deeply penetrated, the disease which it produces causes death ; it even takes place when it is introduced into the cellular texture ; in the muscle or at its surface, it produces a severe but seldom a fatal disease ; after having killed one animal it may kill another. It has no action or only a very weak one upon some of the membranes, the pericranium, the periosteum, the dura-mater, the bones, the marrow, the sclerotic, and the cornea. The wound made in the comb of the cock by a venomous tooth, is followed by a vesicular tumour in the wattles of this animal ; a wound in the nape of the neck in Guinea-pigs, produces a tumour upon the breast or the chin. When the noses of rabbits or of Guinea-pigs are wounded, it swells ; a tumour is formed under the chin and those animals recover ; in dogs and cats, the same bite, repeated to the number of four and twenty times on the nose, produces a considerable inflation, without wound or scar, and they recover in a few days.

The venom does not act upon separated members and muscles, though applied at the moment of amputation ; it requires a communication in the living parts in order that its action shall take place. Its action announces itself after twenty seconds by the lividity which it produces ; if the bitten part is amputated before this period there is no danger ; when twenty-five

five seconds have elapsed after the bite, it is too late.

The venom produces two diseases, the one external, followed by lividity, swelling and mortification; the other internal, affecting the blood, the large vessels, the heart, and the lungs.

When injected into the jugulars of rabbits in the dose of some drops diluted with water, the venom immediately kills them, with a pain which causes them to omit piercing cries. The blood is found coagulated and black in the ventricles and auricles, and black and liquid in the other regions; the lungs spotted and distended, and the intestines inflamed as well as the muscles of the abdomen and the thorax. The venom mixed with six or seven parts of blood at the moment when it is drawn, prevents it from coagulating, blackens it, renders it fluid, and prevents the separation of the serum. The cause of death in consequence of the venom, is the alteration produced upon the blood, and consequently upon the vital organs, which lose their irritability and go on rapidly towards putrefaction. Animals with cold blood, die much more slowly of it, because they can dispense for some time with respiration and motion without perishing.

16. M. Fontana, has terminated his experiments with numerous trials of a multitude of substances or means that have been proposed for curing the disease produced by the bite of the viper. He has ascertained that ammonia,

the acids, and the salts in no wise diminish its dangerous effects; that the oils are of no use; that cantharides are ineffectual; Peruvian bark little efficacious; theiraca of no effect; the fat of the viper as well as hartshorn calcined to blackness entirely inert; that scarifications and the application of electricity are more prejudicial than useful, by accelerating and augmenting the local disease; that the warm bath diminishes the danger, which ceases on a speedy amputation of the bitten part; that the application of leeches and suction are of no utility; that ligatures sometimes effect a cure; that the lapis causticus is the only constant and certain specific when it is mixed with the venom, or when it can reach it before it has entered into the circulation; that this remedy fails when the very small wounds are closed by the elasticity and contraction of the parts: finally, that the virtues attributed to some remedies, and the cures that have been thought to be made upon bitten persons by them, depend upon the circumstance that it was not known that men do not die of these bites, but experience only more or less violent diseases, which is however curable by the mere powers of nature; in fact, this disease may be aggravated by fear, by the moral affections, and even by the inconsiderable remedies which are generally prescribed. M. Fontana has calculated, that if a thousandth part of a grain of the venom of the viper is sufficient to kill a sparrow that weighs an ounce;
if

if it requires five or six times as much to kill a pigeon of the weight of ten ounces, it would require twelve grains to kill an ox weighing 750 pounds, and three grains for a man weighing 150 pounds; that is to say it would be necessary to accumulate the bites of twenty vipers, in order to produce the death of an ox, and of six to kill a man.

17. The state of the science permits me to add to these results of M. Fontana, that potash or the solid caustic fixed alkali, is probably not the only remedy capable of destroying the dangerous properties of the venom of the viper, that several caustics, by disorganising the solids of the animals, and suddenly altering the nature of their liquids, may answer the same purpose if administered soon after the bite; that the nitrate of mercury, that of silver and especially the sublimed muriate of antimony, which are employed with such decided success for changing the nature of the hydrophobic virus, cannot fail to exert the same energy upon the venom of the viper: that there is reason to believe that the oxygenated muriatic acid will have the same advantage, as it is so well adapted for changing the nature and properties of the animal liquids, and as experience has confirmed what I first announced respecting its energy in destroying the variolous virus. But in order that all these re-agents may act as real counter-poisons, it is necessary that they should be speedily, and certainly introduced.

into the wounds ; that they should be brought into exact contact with the venom ; that they should reach it before it has been able to penetrate into the vessels, and that their administration should be conducted in such a manner as to leave no doubt in this respect.

ARTICLE XXXI.

Of some Matters peculiar to Fish.

1. THE fishes do not furnish to the arts and human industry so great a number of matters as several other classes of animals. They afford a large quantity of alimentary matter, and numerous nations live upon their flesh which is no less various than wholesome. It is sufficiently known what differences of taste, colour, consistence, and digestive property, this kind of nourishment presents. We know in this kind of flesh the very remarkable differences between that of the fishes, of the fresh-water, the river, the rivulet, the brook and the stagnant waters, of those that inhabit clear and those that dwell in muddy water, of the fishes that swim at the surface, and of those that keep at the bottom of lakes. The causes of all these differences, which the palate appreciates so exactly, and which are no less distinguishable by the stomach, have not yet been investigated by chemical analysis, though they

they promise useful discoveries and important results for the science of nature. It is necessary to determine what distinguishes the nature of the flesh of fishes from that of birds and mammiferous animals; and this object is important for the advancement of physics.

2. Credulity, and the hope of assuaging or curing diseases, had formerly introduced into medicine several matters, liquid or solid, belated to fishes, which the discoveries of our age have caused to be rejected and ranked amongst indifferent substances: such are the bones of the head of several of these animals, those which are found near the vertebral column of the carp, the elongated bones of the interior of the head of the pike, and the whiting which believed to be the organ of hearing; marvellous properties attributed to them, which it is useless here to call to recollection. The qualities of the gall of the pike, of the tench, of the eel, and especially of the eel were also much extolled. To their highly exalted stomachic virtues, particular and specific virtues were ascribed, which a more rational examination has entirely rejected. In considering here, under their general relation, the principal utilities and products of fishes in the arts, independent of alimentary property, I confine the matter to those that are borrowed from this class of animals to four principal substances; namely, isinglass or fish-glue, the oil which is extracted from
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several fishes, the scales with which they are covered, and the bones which constitute some portion of their skeletons.

A. Of *Isinglass*.

3. ISINGLASS or fish-glue, is a dry, white, semi-transparent matter, bent into the shape of a lyre, and formed of a membrane rolled together. It is prepared upon the borders of the rivers in the vicinity of the Caspian and Black Seas, by taking out the stomach and large intestines of the great sturgeon, *acipenser huso*, rolling them into a kind of cylindrical cords, after having cut them longitudinally, then expressing them, and drying them in the air suspended to strings, to which they are attached by their two extremities: when these membranes are almost dry, the form of a lyre is given to them. The fibrous and elastic texture of isinglass, prevents its becoming dry and brittle, like the glues. It may be prepared with all the parts, and especially with the air-bladders of fishes of a large size. That which is very white and of a fine texture, is preferred.

4. Fish-glue is of a faint and insipid taste. It burns upon ignited coals, shrinking together, and diffusing a fetid smell, like all the animal substances; distilled in the retort, it affords the same products with these substances, and especially

cially a pretty considerable quantity of oil and carbonate of ammonia. It is unalterable in the air, on account of its dry state; cold water softens and separates the lamellæ of the isinglass, with the aid of maceration. By this means we may unfold, and at the same time extend it. Boiling water dissolves, and gives it the form of a jelly; accordingly, it is ranked amongst the gelatinous substances. The weak acids dissolve it, and the alkalies precipitate it from them.

5. Isinglass may be considered as an alimentary matter: softened or dissolved in water, it forms a very nutritious jelly, to which only the seasoning need be added: accordingly, it forms the base of a great number of dishes for the table. It is associated with the acid juices of fruits, with aromatics, and with sugar.

Considered in a medicinal view, isinglass is ranked amongst the emollients, relaxants, in-crassants, it is prescribed in diseases of the throat, the intestines, the urinary passages, and even in affections of the lungs.

Its most frequent domestic use is in the clarification of liquors, of wine, of coffee, &c.; small fragments are thrown into boiling coffee, and it becomes clear in a few minutes.

B. Of the Oil of Fish.

6. WE must not confound, under this denomination, the oils which are extracted from the bale : we here treat only of the oil of fish, properly so called, of that which is extracted from herrings, and a great number of other fishes, collected, after having been heaped together for some time, either to the operation of press, or to the action of boiling water, at the top of which the oil collects.

No animal matters are more replete with fat and oil, than the flesh of fishes. The difference of the organ of respiration in these animals, the little evacuation and combustion which the carbonated hydrogen experiences with them, easily explains the source of the oily vice, so abundantly formed, and diffused in their organs. Accordingly, they are almost all capable of affording this product, though it is extracted only from those which are the most numerous, which live in shoals, and which are caught in great abundance.

7. All fish-oil has a fetid disagreeable smell, and it is difficult to conceive how some nations can use it as seasoning and aliment. It has an analogy with whale-oil ; it burns easily with a white flame ; it is congealed by a slight degree of cold, and seems pretty easily to assume the crystalline form. It also appears susceptible

of being quickly changed into an adipocirous matter, of which it contains a portion ready formed. By repose, are separated from this oil, flakes and laminæ of matter, similar to spermaceti, which deposit themselves at the bottom of the vessels in which it is kept.

Fish-oil is chiefly employed in the arts that are practised upon skins, in order to soften them and preserve their pliability: it is also used in lamps. Some indigent nations use it as aliment.

C. Of the Scales of Fish.

8. THE scales of fish are remarkable for the beauty of their colour, and the silvery lustre of their surface; for their structure and reciprocal arrangement, which forms a continuous integument for the whole body; for the oily and mucous humour, which renders them impenetrable by water; finally, for their nature, analogous to that of horn or tortoise-shell, which, whilst it gives them solidity, preserves in them a flexibility and elasticity, whereby they are enabled to accomodate themselves to all the changes of form which the bodies of fishes assume. The scales adhere to the skin, with which they appear to be continuous at their margins; they also resemble it in texture, and present the same chemical properties. Long ebullition in water, softens them, fuses them, and changes them into

to gelatin, less quickly indeed than the skins of fishes deprived of scales, or covered with small and thin scales, such as those of lampreys, and especially of eels, which, it is known are employed in the preparation of glues, used in tanning.

9. In several species of chondropterygian fishes, the skin, when deprived of scales, is frequently charged with hard, cartilaginous or bony tubercles, susceptible of polish, tinged in some species with blue, green, and grey colours. This tuberculous skin, is employed for turning and covering several small pieces of furniture, that are liable to blows or friction. The hardness of these tubercles, when they are all equal, and close, renders the skins of some of these fishes very useful to be employed like soap or file by cabinet-makers.

10. The most ingenious use to which the scales of fishes are applied, is in the fabrication of artificial pearls. In order to give to the small pieces of thin blown glass, with which they are fabricated, the pearly brilliancy which characterizes the natural pearls, a mode has been contrived of attaching the fine silvery scales of sea-water fishes to their interior surface. The fish, *cyprinus albula*, a small river-fish, one of the most brilliant and silvery that is known, furnishes in its thin and delicate scales, the colouring matter of the false pearls. When these fishes are taken with nets, they are rubbed against each other in buckets under water ;

the scales detach themselves, and sink to the bottom of the water; they are collected and slightly dried; they are afterwards put into liquid ammonia a little diluted, in which they soften, and this liquor is blown into the glass pearls, upon the sides of which the scales apply and glue themselves: it is called *essence orientale*. The ammonia preserves the scales with their brilliancy and freshness for several months.

D. Of the Bones of Fishes.

11. THE skeletons of fishes vary in the different orders of these animals. Two kinds of them are distinguished; the one soft, pliable, semi-transparent, similar to cartilage, on which account the fishes in which it exists have been called *cartilaginous*; these bones are found in the skate, the sea-dog, &c. The other is solid and truly osseous; all the bones of this kind, terminate in sharp points, on which account, the fishes in which they are found have been designated by the name of *spinous fishes*. The analysis of these bones has proved that they consist, like those of the mammalia, and of the birds, of phosphate of lime mixed with gelatinous matter; the latter substance abounds more in them, than in the bones of the preceding animals.

12. Besides

12. Besides the domestic uses, to which several nations, little advanced in civilization, employ the teeth, the vertebræ, and other bones of fishes, substituting them instead of iron, which they have not, for fabricating their hunting and fishing instruments, and different utensils, I have already indicated the properties that were attributed to the bones of the head of the pike, the carp, and the whiting, and the general use that was made of them in medicine. It should be known that after the vain hopes entertained respecting the properties of these bones, had been relinquished, it was imagined that it would be adopting an exact idea concerning them, to rank them in the class of the absorbents. This was a new error, substituted in the place of the ancient one. The bones of fishes are not formed of carbonate of lime; the phosphate which constitutes them, cannot be considered as absorbent, as it does not attract the weak acid of the primæ viæ, with as much energy as the calcareous carbonate does. Accordingly, the bones of fishes, to whatever species they may belong, have not the qualities that had been attributed to them, nor can they fulfil the indications, to which they were formerly destined.

ARTICLE XXXII.

Of some Matters peculiar to the Mollusca.

1. THE molluscæ, a class of animals without vertebræ, without interior skeleton, with cold and white blood, whose muscles are white, and very irritable, their skin humid and viscid, provided with tentacula, whose body is covered with a tegument, and frequently inclosed in a shell, which have the property of reproducing several parts of their body, when cut off, which, for the greater part inhabit the sea, or fresh water, present a great number of objects, with which it would be useful for chemistry to occupy itself. Such are especially the gluey and viscous humour of slugs which cover the places over which they crawl, with a slime, which hardens and appears to be calcareous; the soft, insipid, and gelatinous flesh of snails, which has been considered as proper for curing pulmonary affections; the white or blueish liquor, which supplies the place of the blood in the cuttle-fish and polypi; the colouring matter of the murex or purple-fish, which the ancients valued, and used so much; the threads, the silk or byssus which proceed from several shells

and by which their inhabitants attach themselves to the rocks, all is replete with subjects for singular researches and discoveries in this class. Amongst the most generally known and useful objects relative to it, I shall treat in particular of the ink, and bone of the cuttle-fish, of pearl, of mother-of-pearl, of shells.

Of the Ink and Bone of the Cuttle-fish.

2. THE cuttle-fish discharges, when menaced with any danger, exposed to blows, and especially when it is attempted to take him, a black quid, which has been called ink, and which, forming a dark cloud round him, enables him easily to elude the search, and the view of his pursuers. This liquor, prepared in the body of the fish, by a peculiar glandular apparatus, is contained in a reservoir, which may be taken out, and in which we may obtain their ink, hard and brittle by desiccation. It is believed, that it is with this kind of atramentary animal juice, that they prepared in China, the solid ink employed in drawing, which is so remarkable for its indelibility, and its power of resisting the acids. It appears, that the ink of the cuttle-fish is actually a sort of coaly precipitate, insoluble in most re-agents, and suspended in a mucous liquor. It presents to the chemists who inhabit the sea-ports, a very interesting subject of experiments, for determining its nature, and ascertaining

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ascertaining its utility in the arts : a truly inimitable ink might be prepared with this juice.

3. The common cuttle-fish, *sepia officinalis*, contains towards its back, an oval, thick, solid friable body, which is called *cuttle-fish bone* and which is formed of thin plates, with numerous cells between them, in which are placed small hollow columns, perpendicular with those plates. The nature of the body is gelatino-calcareous; it affords quick lime by calcination, and jelly by long ebullition; it softens very quickly in the acids; which dissolve it with effervescence. It is separated and dried in order to employ it for several domestic uses. It is recommended in medicine as astringent, detergent, and at the same time aperient and emmenagogue. It is an ingredient in ointments, plaisters, powders, and collyria; it has been especially employed in tooth-powders. It is also employed for making some small moulds for casting pieces of silver-ware; finally, it is suspended under the name of sea-biscuit, in the cages of small birds, who amuse themselves with picking at it, undoubtedly on account of the saline taste left in it by the sea-water, with which it has been penetrated.

B. *Of Pearl and Mother-of-Pearl.*

4. Pearl and mother-of-pearl are two concrete matters, formed in several species of shells, or constituting part of them. Though most shells can furnish these two kinds of concretions, it is nevertheless, from some particular species of muscles and oysters, that those precious matters are extracted. They are rare in Europe, and their lustre is not comparable to that of these productions in the oriental regions.

The river muscles, especially that of the Rhine, *unio margaritifera*, *mya margaritifera* of Linnæus, afford only an indifferent mother-of-pearl, in comparison with the *avicula margaritifera*, *mytilus margaritiferus* of Linnæus, which inhabits the Indian seas, and from which the finest pearls and the most highly esteemed mother-of-pearl are extracted.

5. The name of mother-of-pearl is given to the interior portion of most of the shells, whose fine and beautifully polished texture is combined with the white silvery colour, and variegated with green, red, blue, and all the colours of the rainbow. We distinguish zones in it, which seem to indicate inequalities, projections, and streaks at its surface, and which produce a great deception of the sight. After having lawed or corroded by acids, the exterior

part of the shells, as far as the layer of mother-of-pearl which they contain, the various forms requisite for a multitude of different utensils, are given to it by turning, chisseling, and several different operations, it is even softened and bent with the aid of boiling water. It was formerly ranked amongst the absorbents; and its chemical nature actually allows us to admit this medicinal character in it; but there are so many other more simple and more easily procurable substances, which enjoy it in a much higher degree, that it has never been really employed for this use; it is reserved for the fabrication of jewels.

6. The pearls, *margaritae, uniones*, vary greatly in their form, their size, their colour, their beauty, and consequently in their price: they are generally irregularly roundish, or a little oblong, sometimes pyriform, white, brilliant or grey, with silvery and coloured reflections. The brilliancy produced by these reflections, is called the *opalising of pearls*; the small and more irregular pearls are called *seed pearls*; the large and spherical ones are scarce and dear. Very singular opinions have been entertained respecting the origin of these concretions. The ancients believed them to be formed of dew drops, collected in the month of May at the surface of the water, by animals that produce them. It is known, however, that the molluscæ do not quit the ground and the bottom of the waters in which

which they have been produced. Some naturalists have imagined the pearls to be an animal with a shell growing within another; imperfect observations have given rise to this system. Some learned men think that the pearl is a morbid concretion, arising from a puncture made in the shells. They assert, that pearls may be made to grow artificially, by perforating the shells of oysters or muscles, which contain them with holes. According to the most common opinion, they are simply regarded as a concretion, arising from the superabundance of calcareous matter.

7. Accounts no less various have been given respecting the seat of the pearls in the shells which contain them; the thickness itself of those shells, and the cavities announced externally by protuberances, even the hinge of the shells, or the prominent part of their articulation, and especially the ligament that attaches the two valves together, the fleshy body of the testaceous animals which inhabit them, or the interior of the shell in which they are found free and floating, as it were; these four situations have been successively assigned to them. It appears that they are most frequently placed towards the edges of the shells, inclosed under a membrane, which covers the mother-of-pearl, either lodged in cavities which this presents, or floating freely in the shell, or adhering to its internal surface, so that we are obliged to pull them away or detach them with more or less force

force. It also appears, that the experiment of causing them to grow artificially, by means of wounds made in the interior of the shell, is not without success; and this accords with the anatomical facts which prove that wounds made at the exterior of bones, produce an internal osseous concretion or as those which are made towards the interior, or towards the marrow, or give rise to external osseous circles, exostotic swellings.

8. The pearl, as well as the mother-of-pearl, from which it differs only by its finer texture, is a compound of gelatinous matter and carbonate of lime. Cartheuser asserts, that the first of these substances constitutes only the twenty-fourth part of it, and that the twenty-three others are formed of the matter, which he calls *earthy* or carbonate of lime; but we must include the water, which appears to be very abundant in this concretion. It is evident from this composition, that the pearls must be easily soluble, even in the weakest acids, and hence Cleopatra was able, if we may believe the Roman Historians, to swallow beautiful pearls dissolved in vinegar, in order to demonstrate her magnificence and wealth. But it is difficult to conceive from whence the opinion has arisen, which has been entertained respecting the great virtues of pearls, and why they have been regarded as analeptic, sedative, cephalic, antiepileptic, bezoardic and cordial. They have been prescribed, pulverized, in emulsions, and potions or mixtures, principally

principally to quiet the anxieties produced in intermittent fevers. They were afterwards reduced to the simple quality of absorbent substances, and since then, they have not been employed in medicine. Their use has long been confined to the purposes of ornament, to which they are employed, either alone or combined with a great variety of different jewels which they decorate and enrich.

C. *Of Shells.*

9. **THE** shells, so various in form, colour, and use, which serve, by the diversity of their structure, to characterize genera, and by their colours or their appendages, to determine very numerous species, the collections of which, form so pleasing a spectacle, and present even to the learned, a series of interesting data, reflecting the structure and the properties of the animals which inhabit them, amongst the innumerable varieties of these productions, offer to the chemist only one single substance, perfectly homogeneous compound of carbonate of lime, mixed with a little gelatinous matter, decomposable into quick lime by heat, soluble with effervescence by all the acids, and sometimes containing a small quantity of muriate of soda.

10. The chief and most useful purpose to which shells have been applied, relates to the construction

construction of edifices. They afford very good and very pure lime, which is employed in all places in the vicinity of the sea. It was formerly believed that the lime of oyster-shells had very distinguished medicinal properties, superior to those of the common lime; it had consequently been highly recommended in the diseases of the urinary passages, and especially in the gravel and stone. At present, it is supposed that it cannot have any quality peculiar to itself, unless we consider as such the small quantity of sulphurated hydrogen gas, which is formed during the calcination of the shells, and which impregnates the lime-water which it affords, but it is known that this sulphurated hydrogen can have no solvent action upon any of the constituent materials of the urinary calculi.

ARTICLE XXXIII.

Of some Matters peculiar to Insects and to Worms.

1. INSECTS, whose history is so interesting, whether on account of the beauty of their forms, of their colours, and of their varieties, or in the study of their structure, their manners, their police, their combats, their habitations, the injury or the services which they do to man, furnish

with a pretty considerable quantity of useful ducts, or pernicious substances, the knowledge of which is of importance, in order that may derive from the first, all the advantages which we can expect, and repel, or at least rectify the troublesome influence of the second.

I shall distinguish, especially amongst the most useful materials which we borrow from the class of animals, the honey and the wax, cantharides, the millipedes, the ants, the mulberry-lac, silk, cochineal, kermes and the crab-apples, of which I shall treat in particular in this article. To these I shall subjoin the lumbrici, or earth-worms; the only animals, which, amongst the pretty numerous class of worms, employed for several uses, upon which chemistry may throw some light.

It is evident, that I omit in this catalogue several insects, or several of their products, either because they are rarely used, or because their uses have but slight relation with chemical knowledge; or finally, because I shall indicate some of them in treating of the species or materials with which they have an analogy; I do not speak of some species of scarabei which have been proposed in medicine, of the wood-lice, the horns of the stag-beetle, of the scarabæus monoceros, of the meloe, which has been given as a specific in hydrophobia, of the scorpion, of the crysomelæ and lady-birds, which are asserted to be capable of allaying the
the

the pain of the tooth-ache, by their mere contact, and which appear to communicate this property to the fingers which have touched them, of the coffus which were eaten by the animals, of the locusts which serve as nourishment to the acridophagi, &c.

3. Neither shall I treat of all the pernicious insects, with which most naturalists have particularly occupied themselves, as eating and destroying cultivated plants, consuming the harvests, &c. and the substances employed in buildings and clothes. I shall likewise pass over in silence, all the animals which belong to the province of natural history, strictly so called; the May bug and its larva, weevils moths, fermites, scorpions, mole-crickets, and a number of other destructive animals. I shall also neglect those which attack man, and living animals, which sting them, suck them, and expose them to diseases or accidents, more or less severe, such as the bees, wasps, hornets, scorpions: the last-mentioned insects, however, produce an acrid humour, of which a knowledge may be acquired by chemical experiments. Mr. Fontana has already subjected this humour to some experiments, from whence it results that with some physical properties, and especially a gummy viscosity, analogous to the venom of the viper, it contains also an acid ready formed, which renders it susceptible of reddening paper, stained with the juice of radishes, and even of altering its colour. The humour of bees, received upon glass, dries more slowly than

than that of the venom of the viper; fissures and angular lines are formed in it, which were taken for saline crystals by Mead; when dry, it dissolves in water, but not in alcohol. Though it contains an acid, it cannot act by this principle, on account of the small quantity and little sensibility of it. It is by being a venomous matter, that it produces pain; and there is reason to believe, that were it sufficiently abundant, it would occasion death, or the same disease as the venom of the viper.

A. Of Honey and Wax.

4. HONEY and wax, though of vegetable origin, since the first is only the nectar of flowers, and the second the pollen of their antheræ, both collected by the bees, are nevertheless produced by these insects, which give them some characters of animal substances. Though the extraction and formation of these two matters are generally attributed only to the bees, there are, however, some other insects of the same class, which produce analogous substances; but they are in such small quantity, that they cannot be extracted or compared with accuracy. In another point of view, honey and wax may be considered as materials of plants, since honey is nearly pure nectar, and since the fecundating powder, the pollen

pollen of the flowers has very marked analogies with wax.

5. A great analogy has long been established between honey and sugar, both on account of its taste, and the use which the ancients made of it, who knew the sugar of the cane but very little, and did not employ it. But, besides the difference of taste which exists between those two substances, and which is such, that persons habituated to sugar, can no longer use honey, the aromatic smell, and the nature more or less animalized which distinguishes this product of the bees, does not suffer it to be confounded with sugar, properly so called. Honey, whose colour, consistence, taste, and smell, vary greatly, according to the countries and the plants which the bees inhabit, or visit, gives, by the action of fire and by distillation, the same products as sugar; the nitric acid converts it into oxalic acid; it is very soluble in water; it is even deliquescent; it passes into the vinous fermentation, and forms a fermented liquor, which is called *hydromel*; it is partly soluble in alcohol, by means of which, a real concrete sugar may be extracted from it; it is even pretended, that the ancients gave it this form. It is whitened by dissolving it in water, and heating its solution with charcoal.

6. If we compare honey with sugar, notwithstanding the small dissimilarity which chemistry finds between these two bodies, we perceive

ceive that honey really differs from sugar by a somewhat acrid or faint taste, by a gold-yellow, greenish, or brown colour, by an aromatic or strong smell, by a liquid, or viscous, thick and ropy state, and by its deliquescence. If we investigate the cause of this difference, we shall find it in the presence of a colouring matter, of a mucous substance, of a sapid and odorous extract, which appear to be united with the saccharine matter, and not to be separable from it without much difficulty. It is to these particular properties, that the relaxant or purgative nature of honey is to be attributed, as well as the disgust which it gives to many individuals, who can consider it only as a medicine. Hence it is at present ranked more particularly in the class of remedies; it is reckoned amongst the laxatives, the emollients, the bechicks, &c. It forms the excipient of many remedies, which are called compound honeys, such as the honey of roses, the mercurial honey, the honey of nenauphar, &c. It is frequently combined with vinegar, and this mixture is called *oxymel*.

7. The wax does not exist ready formed in the powder of the antheræ, whence the bees extract it. No artificial means have yet been found for converting this pollen into wax; it is only the body of the bee that effects this conversion. After having swallowed the powder of the stamina, these insects discharge it in the form of ductile wax, by a kind of transpiration

which takes place between the rings of their abdomen, according to several observers, or by the mouth, with the aid of a kind of rumination, according to others. Some modern naturalists do not believe that the powder of the antheræ is the primitive matter of the wax, notwithstanding the observations of Reaumur and B. Jussieu. M. Della Roca, thinks that the wax is a vegetable substance, foreign to the pollen of the antheræ; that the open flowers furnish only nourishment to the bees; that it is upon the buds of the thyme, upon the leaves of the fig, covered with small tubercles, and perhaps upon the sprouts of the poplar, and the extremities of the fir, that they collect the waxy substance, which appears certain, with respect to the two last-mentioned trees, relative to the collection of the propolis; that the plants contain the wax ready formed, and that the bees only purify it. But the propolis is not wax, strictly so called, but appears rather to be a resinous mixture, which has not yet been examined. Some naturalists think also that the matter of the wax collected by the bees, does not pass into their stomachs, but that it is fabricated by the mere action of their mouths, and their paws.

8. The nature of wax is better known than its origin. Constructed into solid cells by the bees, it is turned yellow by the vapours, and liquids that issue from their bodies, as well as by the colouring parts of the vegetable matters, which they carry into their hives. Fused by a gentle heat,

heat, and deprived of the honey which it contained in the cells, it is run into thick, yellow, granulated cakes of rough wax; it is then melted, and in this state poured into a cylinder, half immersed in water, and which is successively immersed in it in all its parts, by a rotatory motion round its axis, imparted to it by a very simple mechanism. Rolled into thin ribbands by this first operation, it is afterwards exposed to the air, and to the sun, upon tiles, in order to bleach it, and when it has lost all its colour, it is improperly called *virgin-wax*. In this last state, it is employed for a multitude of pharmaceutical and domestic uses: in that of raw wax it is likewise much employed.

9. All the properties of wax prove that this substance is a fixed oil, concreted by the proportion of oxygen which it contains. It is softened by a gentle heat, and assumes all the forms which we choose to give it. At a low temperature, it is brittle, and shows a granulated and crystalline texture in its fracture. It melts at 45 degrees of the thermometer; it then presents a white and transparent liquid; more strongly heated, it is partly volatilized at a very high temperature; it is decomposed into water, sebacic acid, carbonated hydrogen gas, and an acrid oil; it then leaves some coaly marks. The concentrated acids burn it; the alkalies reduce it to the saponaceous state; pot-ash and soda particularly form with it a soluble soap, which is frequently employed by the name of *emulsiue* for painting pannel. It unites with

12. These four immediate materials of the cantharides are, separated from each other by water, alcohol and ether; hot water dissolves the extract, and melts the yellow oil; it even separates a part of the green oil; ether attacks the latter so well, that it may be employed with advantage for extracting it pure. This process is the more useful, as it is in the green wax that all the virtue of the cantharides appears to exist. A mixture of equal parts of alcohol and water, takes from these insects the green wax, and the extract which they contain, so that it is the most certain solvent which can be employed for preparing an active tincture of them. If we distil this tincture, the alcohol retains a slight smell of the cantharides, and the matters which it has dissolved, separate in proportion as the evaporation takes place. From 576 parts, (grains, or one ounce) of these insects, which he took for making his experiments, he obtained 233 of solid and insoluble parenchyma, 216 of bitter extractive matter, 60 of green, acrid, and odorous wax, and 12 of colouring yellow wax.

13. The vesicatory effect produced by the application of pulverized cantharides to the skin is well known. Mixed with ointments, they form the epispastic most generally employed, or the most common blistering-plaster. They produce a very singular action upon the bladder; the irritation which they produce in it, excites pain, a sense of acrimony, a difficulty

culty of making water, on which account they have been ranked amongst the hottest diuretics. This action is moderated, and almost annihilated by camphor, when mixed either with the vesicatories, or with the tincture. Cantharides have been sometimes recommended as a powerful aphrodisiac, but many examples have proved that the slightest use that is made of them for this purpose, is an abuse which is frequently followed by fatal consequences. In all cases, enlightened and prudent physicians never direct the internal administration of cantharides, or of any of their preparations, unless with the greatest circumspection, and in the weakest doses. We ought also to distrust the great hopes which have been formed of the effects of this violent remedy, in very severe, and even incurable diseases. The green wax of the cantharides applied to the skin, produces a blister filled with serosity.

C. *Millipedes.*

14. Wood-lice, *millipedes*, *afelli*, *onisci*, *porcelli*, are very well known insects, of which there are several species, amongst which that which inhabits low situations, and moist cavities, has been selected for medicinal use, or else that with a grey shining body, which is found under stones, and which, as it rolls itself together so as to form a ball, has on that account

count received in French the appellation of *porte armadille*. Thouvenel has examined the insects, on the nature of which, nothing had been said before his time. Distilled alone in the water bath, they yielded water sufficiently alkaline to turn the syrup of violets green: by this distillation they lost $\frac{1}{4}$ of their weight. Treated afterwards with water and alcohol, they yielded a fourth of their weight of extractive and gummy matter, which either separated from each other by dissolving the latter without touching the former. The expressed juice of these insects appears to contain muriates of potassium, and lime. The physician whom I quote has affirmed the aperient and solvent property of this juice in the jaundice, serous, lacteal effusions, &c. but in a much stronger dose, is generally prescribed.

D. Of the Ants, and of the Formic Acid.

15. In chemical analysis, ants present results of much greater importance than most of the other insects, on account of the well characterized acid which is extracted from them. Langham, Tragus, Brunsfeld, and J. Barthe discovered it by the red colour given to flowers of endive in an ant's nest. Sars, Fisher, Etmuller, Fred. Hoffman, afterwards occupied themselves with it in particular. Berzeliuss, investigating its character, verified its particular nature, and already found in it fixed oil, and an extract. In more modern

times, Thouvenel, Ardviffon, and Oehrn, Afzelius, and Fontana, have made experiments upon this animal acid, and have determined its attractions and nature.

16. It is well ascertained that ants, especially the red, *formica rufa*, exhale, when collected in a mass in a close vessel, a pungent acrid odour, which draws tears from the eyes and excites sneezing. The air is speedily altered by this vaporous body, and it soon ceases to support combustion; it precipitates lime-water, and reddens the tincture of turnsole. Thus the ants convert the atmospheric oxygen into carbonic acid, and a part of their own acid is converted into vapour; when they are irritated, they discharge from their mouth a drop of brown or reddish liquor, very acrid, and very acid; crushed upon paper stained blue with turnsole, they give it a strong red tinge; frequently even they produce streaks of this colour upon the light-blue flowers, over which they creep: thus their acid nature is well marked, and all the experiments to which they are subjected, furnish unequivocal proofs of it.

17. The acid of the ants has been extracted by three different processes; by distilling them in the retort, by lixiviating them with hot water, and by extending pieces of linen impregnated with a solution of pot-ash in an ant's nest. In the last-mentioned case, the acid is combined with the alkali; the two first means have been preferred. The very acid liquor
which

which is obtained by the distillation of dried ants, by a well conducted fire, is covered with a little oil. This acid amounts to nearly half of the quantity of the insects; its weight is to that of water, as 1,0075 to 1,0000. When it is extracted by means of hot water and by washing the ants, it is mixed with an oil. It has been advised to boil it, in order to purify and preserve it. It is better rectified by distillation repeated several times, till the liquor passes off colourless. When highly rectified, its weight is to that of water, as 1,0453 is to 1,0000. It has a pretty strong and not disagreeable pungent smell; it is acrid to the taste when pure; it becomes agreeable when it is diluted with water; it strongly reddens the blue colours, it is turned black by the concentrated sulphuric acid; it is rapidly decomposed by the nitric acid, and by fire; it yields carbonic acid in this decomposition. It has been compared to the acetic acid; it has been proposed to substitute it instead of this acid for domestic purposes; and it has even been attempted to establish this comparison by positive experiments.

18. Notwithstanding the pretty extensive researches which have been made upon the formic acid for thirteen years past, its saline combinations have as yet been little examined. Thouvenel says that the formiate of pot-ash, or the salt extracted from the cloths impregnated with alkali, and spread out in an ant's nest, crystallizes in flat parallelograms or prisms that
arc

is not deliquescent. The formiate of lime is soluble and crystallizable. The other formiates have not been described. Messrs. Ardviffon and Berthollet have contented themselves with indicating the elective attractions of the formic acid in the following order; barites, pot-ash, soda, lime, magnesia, ammonia, zinc, manganese, iron, lead, tin, cobalt, copper, nickel, bismuth, silver, and platinum. Citizen Deyeux, has carefully examined the acid of ants, and has found it to be analogous to the acetous acid.

19. Besides the particular acid of which I have been speaking, the ants contain a fixed concrete oil, which is extracted from them by the press, after they have been exhausted of all the soluble matter which they contain, by boiling water. This oil amounts to nearly a tenth of their weight; it is of a greenish yellow colour; it becomes fixed at a lower temperature than the oil of olives; it approaches to the nature of tallow or wax. The water of the decoction of ants gives, by evaporation, a sort of brown, fetid, acidulous, and caseous extract, of a sour, bitter, and nauseous taste, from which alcohol and water successively separate two different matters. After the oil and the extract obtained from the ants, treated as has been said, there remains a solid parenchymatous matter, which forms a fifth of their weight. Hoffman, by digesting alcohol upon ants, obtained a colouring and aromatic matter; and he called this tincture which forms a light precipitate with water, *spiritus magnanimitatis*

nanimitatis, undoubtedly on account of its acrid taste and aromatic odour. The smell of amber which the ants have, and which they communicate to all the food which they touch, or in which they remain after having been drowned, is generally known. This smell, which to many persons is insupportable, has undoubtedly led physicians to admit a cordial property in ants. However, I know a fact which ought to inspire some distrust with respect to their medicinal use. A friend of mine having swallowed some ants in water which he drank greedily during the night, was attacked with burning thirst and heat, attended with a sensation of acrimony and acute pain in the stomach. These first symptoms were succeeded by a pretty violent cholic, and an alvine evacuation which lasted several days with violent gripings. This disorder continued four whole days.

E. Of Resin-lac.

20. WHAT is improperly called *gum-lac* in commerce is a resin of a reddish brown colour, semi-transparent, dry and brittle, deposited upon branches, round which it forms a hive or heap of cells which contain the eggs of a species of insect. It was formerly believed to proceed from a species of ant; it is now known that it is a coccus whose puncture produces, upon the young shoot of the *ficus indica*, the *ficus religiosa*,

igiosa, and the *croton lachifcum*, a resinous exudation. They distinguish the lac in grains, in sticks, and in plates, or shell lac. The two first are in the natural state: the last is the resin melted and poured into plates.

21. It was from error that some chemists formerly compared lac to wax; its dryness, its aromatic smell when it is burnt, its solubility in alcohol, constitute it a real resin; nay, it actually belongs to the vegetable substances. I speak of it here only, because it is the constant product of the puncture of an insect, and would not exist without this puncture.

22. There exists in the lac a colouring matter which appears to proceed from the insect to the action of which its discharge is owing, and the young of which are found inclosed in the cells. It was on account of this colouration, and of the cells destined to lodge the young, of which this concretion is formed, that Geoffroy compared this resin to wax. It is asserted that this resin is employed in India for dyeing cloth, and in the Levant for dyeing the leather called Morocco-leather.

Its great use is in the preparation of sealing-wax, of which it forms the base. It enters into the composition of the thick varnishes of China and Japan, on which account they are called *laque*, or *vieux laque*.

Some use is made of it in medicine as an external tonic and a stringent; it is an ingredient in the *Trochisques de Karabè*; in the powders and opiates

great force. The multiplied uses for which it is employed are well known, as well as the abundance of this production, compared with its scarcity a century and a half ago.

25. The silk-worm, contains in a reservoir situated near the anus, especially in the state of crysalis, an acid liquor, which has been examined by Citizen Chauffier. The moth discharges some drops of it, which redden blue paper. This insect expressed, yields a juice which mixed with alcohol, precipitates a mucilage, an oil, and gelatinous matter, and leaves bombic acid in solution. By evaporating this solution we obtain an acid, pungent liquor, of an amber-yellow colour, which turns the blue colours red, and which forms particular salts with these bases. Hitherto, neither the bombiates, nor the nature and composition of the bombic acid, have been examined. It is extracted also by infusing the chrysalids in alcohol. It is destroyed by the action of fire; hence it is not obtained in the distillation of these crysalids. An analogous acid exists in several caterpillars, in that of the willow, and in many insects. But it is not known whether it be of the same nature with the ~~bombic~~ acid, and whether one or other resembles or differs from the formic acid: it may be suspected that they are all acetous acid.

G. Of Cochineal.

26. COCHINEAL is the body of the female of a hemipterous insect, which is produced, grows, is fecondated, attaches itself to and dies upon the leaf of a *nopal* called *cactus cochenillifrus*, from which it draws the juice. Its body dries upon it, and is collected by the natives of South America, who particularly cultivate or take care of this insect. The wild cochineal, which is enveloped in an external spinning is distinguished from that which is cultivated and which loses this covering, at the same time acquiring a greater bulk and a richer colour; this production has long been considered as a seed. It is in Mexico that the cochineal is cultivated, and also spontaneously produced: its form, its structure, the number of its rings, all its characters in short, develop themselves when it is steeped for some time in water.

27. This production gives, by the action of fire, the same results as all the animal matters. Carbonate of ammonia, thick and fetid oil, carbonated and sulphurated hydrogen gas are extracted from it. Its colouring part has been particularly an object of attention, as it is from this that its great use in the art of dyeing arises. It gives a crimson violet colour to boiling water, which is rendered red and yellow by the acids; these frequently precipitate from it a

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fecula of the same or a darker colour. metallic solutions, added to its decoction general, form in it a coloured precipitate. muriate of tin gives a deposit of a beautiful red, which is more abundant when tartar added to the decoction. Treated with alcohol the residue of the evaporated decoction cochineal gives to it a very red colour, which the evaporation of the alcohol acquires form of a resin: this, as well as the dregs of extract not dissolved by the alcohol, yields products of an animal substance by distillation. The decoction of cochineal keeps without putrefaction. The cochineal itself remains more than a century without its nature being changed, in a dry place, according to the observation of Hellot, who employed some which had been kept a hundred and thirty years. The oxygenated muriatic acid turns the decoction of this substance yellow; and we may estimate its goodness, by the proportion of the re-agent which we are obliged to employ in order to discolour it.

28. Cochineal is the most valuable and the most beautiful of the red colouring matters which are employed in dying. The red, crimson, poppy, orange, violet, and scarlet dyes, are prepared with it. The last-mentioned colour particularly is produced by the addition of muriate of tin and of tartar to the decoction of cochineal. Its colouring part differs principally from that of madder by a greater solidity or
unalter-

unalterability: this is the reason why in separating the colour of the cochineal from water, by a substance which precipitates it, its primitive colour re-appears, little changed, though it had been turned yellow by the acids, whereas in the same case the colour of the madder retains a yellow or fawn-cast. Carmine is prepared from the cochineal, it is a kind of lac, precipitated from its decoction, mixed with alum by the alkalis, *autour* and *kouan* are mixed with it, in order by their yellow to render the too deep red of the cochineal lighter, and obtain the brilliant colour of the carmine. Cochineal is also used for colouring several alimentary and pharmaceutical preparations.

II. *Of Kermes.*

29. THE kermes, *coccus infectorius*, is a kind of a violet, or dark red, or brilliant brown gall, proceeding from the female of a hemipterous insect, which fixes itself and dies upon the leaves of the green oak of Provence or of Italy. This female insect in dying and attaching itself, assumes the form of hemispherical cap, in which the figure of the primitive animals is lost. They separate these dry scales, which were for some time considered as tubercles or excrescences of the tree: they have also been considered as the seeds of the tree; whence the name of *kermes-grains*, *scarlet-*

grains. The white down which serves to attach this insect to the leaves, has some characters analogous to those of caoutchouc, according to Citizen Chaptal. This insect is collected in the nights of May and June; the young and the eggs contained under the cases of the female are suffocated by macerating the kermes in vinegar or exposing it to its vapour. It is afterwards dried in the sun upon cloths; it acquires a red vinous colour in this operation. That of Galatia and Armenia, was formerly preferred: at present it is collected in Spain, in Portugal, and in the ci-devant Languedoc.

30. Kermes has all the properties of the animal matters; it gives the same products by the action of fire. Its colouring matter, which forms its principal character and determines its employment is soluble in water and in alcohol. These two solutions evaporated leave a highly coloured extract. When kermes is used in dying, alum and tartar are added. It gives a very lively cinnamon colour with the solution of tin; the alkalies, tarnish its colour. The tinges which it produces upon wool have much less lustre than those of cochineal; but they have much more solidity, and we may remove spots of grease from them without altering the dye of the cloth. The blood-red of the ancient tapestry proceeds from it. Its action is combined with madder for what is called *half-grained scarlet*; the addition of muriate of tin turns the colour of
kermes

kermes yellow, for which reason it is little or not at all employed by the dyers: on account of the solidity and unalterability of this colour, it is to be regretted that it is not more in use at present: in the Levant it is more employed.

In medicine, the kermes was ranked amongst the astringents: it is an ingredient in the syrup of coral and in the alkermes confection, to which it has given its name.

I. Of Crab's Stones.

31. THE crab's stones, which formerly were very improperly called *crab's eyes*, on account of their form, are concrete bodies, rounded and convex on one side, compressed, and as it were hollowed in on the other, two of which are found in the sides of the stomach of this crustaceous animal, at the period when his softened body is disposed to form the calcareous shell which covers it. It is believed, with a sufficient degree of probability, that these concretions, which are found in the crab only at the period when it changes its shell, proceed from a kind of metastasis, which transports the calcareous matter from the exterior of their bodies to the interior; in fact they disappear in proportion as their external covering becomes solid, by absorbing, as it appears, the solid substance which was deposited upon the sides of
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the stomach. These stones vary greatly in size and are produced every year.

32. When the crab's stones have been extracted, they are only dried in the air and the sun, and are afterwards sold for medicinal use: the druggists pulverize them, wash them, and triturate them with a little water; they afterwards form the paste that is made of them into troches, which they dry in the air upon paper: this is what is called *prepared crab's stones*. The water with which they are washed, and especially hot water, takes up from the crab's stones a small quantity of gelatinous matter, which is mixed in them with the carbonate of lime. These concrete bodies are converted into pure lime by the action of fire. Though we have no exact analysis or very strict chemical examination of them, it is known that they are formed, at least for the greater part, of calcareous carbonate. The crab's stones are entirely soluble in the weakest acids. Their medicinal properties are confined to their absorbent or ant acid quality; and it is without reason that they have been ranked amongst the aperient, diuretic, and cordial remedies.



K. Of the Lumbrici.

33 THE earth-worm, *lumbricus terrestris*, the most common of all the animals of the same order, and which inhabits the superficial strata of the earth, from whence great numbers
of

of **t**hem come out during rain, is also the only one that is employed for certain uses, though at **p**resent much less confidence is placed in it, as **a** medicinal substance, than formerly. **A**lthough no true analysis of the earth-worm has been made, we nevertheless know, that by fire the **s**ame products are obtained from it, as from all **o**ther animal matters. Several authors on the **M**ateria Medica have even grounded the **p**roperties which have been attributed to them **u**pon the large quantity of volatile salt and oil **w**hich the worms furnish by the action of fire.

They have been ranked amongst the sudorifics and diuretics, they have been recommended in **t**he calculous affections: they were prescribed dried, and pulverized; they have been especially employed for the preparation of **e**xternal remedies, particularly when boiled **w**ith oil, for the purposes of resolving and **s**trengthening, in sciatic pains and rheumatism. Some authors have also described them as **e**xternal stimulants in paralysis. The lumbrici are hardly used at all in modern pharmacy.

ARTICLE XXXIV.

Of some Matters peculiar to the Zoophytes.

1. **T**HE zoophytes, the last in the scale of animated beings, on account of the simplicity of their structure, frequently resemble branches and vegetable ramification, on which account they
have

have received the name which they bear. Notwithstanding the number of the species and the immense quantity of the individuals which cover a great part of the bottom of the seas, they furnish very few useful products to medicine or the arts. I know only four substances belonging to them which deserve a particular examination, viz. the coralline, the coral, the madrepore, and the sponge.

A. Of the Coralline.

THE coralline is a kind of habitation of polypi, hitherto unknown, and composed of articulations covered with a calcareous integument, the corneous axis of which sends out fibres which traverse the cretaceous substance and go as far as its surface. Its articulations are oval and have their points downwards; its branches dispersed twice in the form of the plumes of feathers, are close to each other, and resemble a very tufted stony bush. There are immense quantities of corallines upon the coasts of the sea; they vary in their colours, which are white, grey, greenish and reddish; they are distinguished by their form and their cretaceous nature from the coralline of Corsica, which is only a species of comerva, or of filamentous fucus, without articulations, without calcareous integument, and which forms with boiling water, in which a great part of it dissolves, a viscous jelly.

3. Coralline

3. Coralline has a saline, acrid, and disagreeable taste, a very sensible fleshy or marsh smell; it crackles between the teeth; it crumbles between the fingers, and readily shows under its calcareous powder its interior corneous stalk. It dissolves in the acids with effervescence, and leaves softened and dilated gelatinous filaments. Water extracts from it by ebullition only a small quantity of gelatinous matter; in the retort, however, it gives very sensible products of an animal substance, and especially carbonate of ammonia and fetid oil. It is reckoned amongst the anthelmintics and astringents; but it enjoys both these properties only in a very feeble degree: it is an ingredient in the anthelmintic powder. Modern authors class it among the absorbents.

A. Of Coral.

4. CORAL, *corallium officinalis, ips nobilis* of Linnæus, a kind of zoophyte well characterized by its solid, stony, red, rose-coloured, or white axis, striated at its surface, covered with a bark of an aurora red colour, having cavities from which proceed polypi with eight dentated tentacula, was formerly very much esteemed and rated at a high price on account of its fine colour and its dense texture, -susceptible of a beautiful polish. Coral is fished for upon many maritime shoals, and under the projections of rocks, especially by means of laths, or bars of iron placed cross-wise, which detach and
raise

raise the branches of this production. The corals, of least value are those in which the polypuses no longer exist, and which have served several other marine animals to fix themselves upon. The living cora is stripped of its fleshy bark, and its strong axis laid bare.

5. The fine smooth polish which may be given to coral, the beautiful red, carnation, or rose-colour which it presents, the solidity of its texture and its inalterability by the air, rendered it formerly one of the material the most frequently employed in the fabrication of jewelry. On account of the advantageous ideas which were at the same time conceived of its virtues, it was cut into amulets, into polyhedrons, into olives, and into spherical and cylindrical forms, it was made into rings, crosses, bracelets, neck-laces, &c.

Since its analysis has proved that it contains only carbonate of lime, a little iron, and a small quantity of gelatinous matter, it has only been ranked amongst the absorbent matters. Great confidence was formerly placed in the combination of the acetous acid or lemon juice with coral, and in the salt resulting from this combination. It was administered as an antispasmodic, sedative, asperient and dissolvent. This is nothing more than the calcareous acetite or citrate. It was made an ingredient in the powder of Guttete, the confection of Kermes, the troches of Karabé.

At present it is employed only in the preparation of powders and opiates for the teeth.

We must not confound with the real coral what is called *black coral*, which is an *antipathe* the axis of which, formed of a corneous substance, dries in the air, and receives a very beautiful polish.

C. *Of the Madreporæ.*

6. THE name of madreporæ is given to all the species of the habitations of polypi, of a calcareous nature, upon which the cavities in which the animals are lodged are disposed in stellated forms. They are distinguished by their form into fungites, meandrites, astroites, porites, millepores, and madreporæ, properly so called, which are characterized amongst all the rest by their branched stalks. These last are sometimes, though improperly, denominated *white coral*. The surface of these apparently stony bodies is entirely covered with a soft and mucous membrane, charged with living tubercles, which are real polypi. These species of animal productions are more especially called *lithophytes*, on account of their solid and stony nature, connected with their form of vegetables or of divisions frequently ramified.

7. The madreporæ separated from the animated mucous layer which covers them, and reduced to the solid base deprived of all the animals which it supported, are only carbonate of lime

in an almost pure state. However, when the calcined, they emit an animal smell; they be black and are converted into coal on account of the small quantity of animal matter which they contain between their interstices; but are soon reduced into lime, of which they afford a very good kind for building. When the madrepores are treated with the acids, are soon attacked with effervescence; carbonic acid is disengaged, and they are entirely dissolved; they scarcely leave a few of very fine lamellæ or detached flakes of gelatinous matter, nearly like those observed in the calculous concretions of phosphate of lime or phosphate of magnesia. These chemical properties prove that the madrepores ought to be considered as simple absorbents.

D. *Of Sponge.*

8. SPONGE, the last degree of animal organization, which, without any organ, presents only a gelatinous integument, the tremulous motion, a slight contraction of which is the only sign of life that can be remarked in it, is composed of a fibrous, flexible texture, full of pores, and cells communicating with each other, capable of being reduced by pressure to a very small space, of afterwards returning to its original volume, absorbing water by a number of capillary tubes, acquiring by this absorption a remarkable

emarkable softness and flexibility, and becoming dry and harsh when deprived of water.

9. Sponge, after the destruction of the animal jelly which covers it, and after multiplied washings, presents only an elastic, insipid, inodorous, fibrous texture, the nature of which seems to approach to that of a prepared skin ; its colour is brown or fawn. It furnishes, by distillation, the ordinary products of animal substances, carbonate of ammonia, a thick and fetid oil ; and it leaves a pretty dense coal, from which muriate of soda and phosphate of lime are extracted. It dissolves with difficulty in the alkaline leys, and the acids alter it after the manner of the animal substances, the sulphuric blackens it, and reduces it to coal, the nitric turns it yellow and reduces it into oxalic acid and fat matter ; it is unalterable by air and water.

10. Besides the economical uses to which sponges are applied in houses for a number of objects of cleanliness, from the coarsest and most voluminous, which serve for rubbing walls, floors, carriages, &c. to those of the finest texture which are prepared for cleansing the skin ; it is useful in surgery for forming kinds of tents and doffils employed for enlarging fistulas, keeping their cavities open, and absorbing their moisture, in medicine burnt sponge reduced to shreds has been much recommended for discussing bronchoceles or goitres, or dissipating scrophulous tumors, &c.

FOURTH ORDER OF FACTS.

Of the Chemical Phenomena which living Animals present, or Applications of Chemistry to Animal Physiology.

ARTICLE I.

Of the Existence and the Kind of the Chemical Phenomena which take place in the Bodies of living Animals.

1. IN a great number of the preceding articles, I have had frequent occasion to show that there present themselves in the middle of the body of animals, and during the enjoyment of their life, real chemical phenomena; what I have said of them, both in the general exposition of the chemical properties of the animal substances, and in the particular history of each of these substances, is however not sufficient to answer the end which I have proposed to myself. I must now deduce from all the facts comprehended in this eighth section the general results which are their true corollaries: I must bring under one point of view and render more striking by their concentration, all the truths scattered in this part of my work: this is what I propose to do in this last order of facts.

It must first be ascertained that there actually is in the bodies of living animals, true chemical phenomena, product and changes proceeding from the intimate attraction which governs different particles of which the organic texture of animals is composed, that animal life exists neither in the purely mechanical play of the organs nor exclusively in a particular principle, a vital principle independent of any natural force, which seems to have been admitted in a celebrated school, after the example of some illustrious physicians of the last century only in order to show the uncertainty and deficiency of the mechanical physiology which had been so much abused. We must explain the kind of chemical phenomena animal life consists of, how they differ from those which are observed amongst the fossils, or even in the animals themselves deprived of life, what their peculiar characters, and how we may arrive at the developement of their various mechanism.

Two general modes of the manner of existence of living animals appear to me to be proper for proving that there take place in them a very remarkable chemical action; that life consists in a great measure in the products, resulting from chemical actions, and that in order to know its nature as far as it can be known by the human mind, it is of indispensable necessity to submit chemical actions to the most attentive examination. We must begin with the animal, at the moment when the germ is first formed, which

which has given birth to it, has received the first vital movement, continues to exist only by the successive addition of matters extraneous to its own body. These matters, received into particular cavities, assimilate themselves to its own substance, become gradually integrant parts of its organs, augment them in weight and extent, assuming exactly their nature. Now the vegetable matter which experiences this assimilation in the animated body, actually changes its intimate nature, and becomes a new chemical compound, different from what it was at first. It is therefore very evident, that this cannot take place without a variation in its combination, without the loss or acquisition of some principle, or change of proportion in those which originally constituted it. This is the inference which must necessarily be drawn from the comparison established between the vegetable and the animal body.

4. If to this first mode, which cannot exist without chemical actions, we add what I here reckon as a second mode of the exercise of life, which proves that of these actions, the observation of the phenomena which continually accompany the functions of living animals, there cannot remain any doubt respecting my present object. In fact, how many phenomena, really chemical, have we not occasion to observe in the bodies of living animals. In all their parts, liquids become solid and concrete, whilst solids melt and dissolve;
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in all of them caloric is developed and propagated, which keeps matters constantly liquid: in some cases, concrete substances are softened and liquefied by a real solution; in others saline crystals, and coagulated flakes are deposited, and attach themselves to one another. In the midst of expansive cavities and reservoirs, elastic fluids are formed and dilate themselves; in tubes curved in innumerable ways, mucous fluids thicken or become liquid, evaporate or condense; insipid and colourless bodies acquire colour and taste; oily bodies are produced, or become saponified; precipitates are formed or disappear; salts change their bases, or decompose each other; other salts are constituted; acids are composed; some alkaline bases even seem to be produced or formed in a direct way, &c.

5. These effects, respecting the existence of which, no doubt can remain in the minds of those who observe without prejudice, and who are able to distinguish the phenomena which nature presents to every eye, in their general results, produce the change of the vegetable into animal matter; a greater complication in the composition, and an augmentation in the proportion of the azote, or a fixation of this principle; a similar augmentation in the hydrogen; a formation of ammonia, and of fat oil, or a great disposition to the production of these two bodies; formation of phosphoric salts; a volatilization of the water, of the carbon and of the hydrogen redundant in the animal composition in

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general; a frequent disengagement of carbon acid gas, or carbonated and sulphurated hydrogen gas; facts and circumstances which have already been often indicated in the article relating to all the animal compounds which have hitherto been considered.

6. But it must also be remarked, that the chemical actions, or phenomena which take place in the bodies of living animals, are not always of the same kind with those to which the animal matters deprived of life are subjected; that nature has frequently imposed upon herself other laws, in this respect, and that it is the more essential to appreciate this difference well, as it has long been the subject of discussion, which has greatly impeded the progress of animal chemistry. Physicians have pretended that the chemical phenomena observed in the dead matters, have no relation with those of life; that the conclusions drawn from the former, which for a long time were exclusively attended to, could not in any wise be applicable to the latter, and that it was impossible to derive any light from them in physiological explanations. Though this assertion is not so entirely true as has been pretended, it nevertheless merits to be examined with much attention since it has deterred ingenious minds from the cultivation of animal chemistry, and has brought its applications to physiology, into much disrepute.

7. If we inquire impartially what is the cause of the difference between the chemistry of living
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ing animals, and that of the dead animal substances, we immediately perceive, that the one being intirely out of the reach of our instruments and our methods of analysis, it is only by the observation of the natural products, that it can be possible for us to arrive at their causes and results; the other, on the contrary, that which the chemist exercises upon the animal matters destitute of the power of life, is entirely at his disposition; he acts upon these matters with means, with instruments, and with re-agents of much greater energy, and which nature does not employ; they are besides in a different condition from the living matters; they have lost their heat, their motion, their communications with the animated, living, irritable, and sensible organs. Every thing in the chemical art is violent, very active, decomposing, annihilating; the analysis is speedily carried to its extreme, to its *maximum*; the separation of the constituent elements is always instantaneous; the decomposition is rapidly completed. In nature, the equilibrium of composition is more stable, the chemical changes take place only in a progressive manner, and, as it were, at their *minimum*. Slight variations in the proportions are sufficient for the successive transitions, and the regular conversion of the matters into one another.

8. Hence it is, that the liquids and organic compounds which constitute the bodies of animals during life, tend to preserve their

state, to remain in their primitive order of combination, and are altered and changed only in an imperceptible manner; they maintain their accustomed temperature and consistence; lose only some of their principles, and these gradually; recover what they have lost in order to continue in the same state; and support this permanency, this constancy of nature in the different regions of the body, in which they are situated, or through which they pass. Upon this depends that incorruptibility, that freshness, that opposition and resistance to the septic decomposition, which forms so decided a character of the living animal bodies, and so striking a contrast with the dead animal matters. And in fact, scarce has an animal compound ceased to participate of the vital movement, when it becomes no less changeable and alterable, than it was permanent and stable under the empire of life; its colour fades, its consistence changes, a smell, at first faint, and afterwards disgusting, exhales from it; fetid elastic fluids are discharged from it; an ichorous sanies is discharged from it. Its texture becomes relaxed, and its putrid nature attests the new alterations, and the rapid decomposition which its elements obey. Thus death is as powerful a cause of corruption, as life is of preservation.

9. But ought this difference, great and remarkable as it is, to prevent our referring or comparing the phenomena which chemists observe in the dead animal matters, with those
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which exist in the same matters whilst living; and may it not become a subject of useful studies or observations? May it not furnish the means of appreciating what takes place in the one, according to what is found in the other? Must we renounce the idea of describing and determining with precision, what takes place in the dead matters, because the same thing does not happen in the living; and can the one of these results be an impediment to the knowledge of the other? I do not think that this conclusion is to be drawn; on the contrary, it is my opinion, that we ought to avail ourselves of the chemical effects which are perceived in the dead animal matters, in order to appreciate what happens to these matters whilst living; and, that we cannot comprehend the changes which the latter undergo, unless we have begun to determine with precision, the changes of which the former are susceptible.

10. Besides, though there really exist differences between the chemical results that are observed in the bodies of living animals, and the products which are obtained from their dead bodies treated by the art, it cannot be denied that there also exist some analogous effects in the two kinds of substances. These differences are within certain limits; they take place only to a certain extent, or only with respect to some properties. It is also to be remarked, that when we announce the chemical properties of the animal

mal matters deprived of life; when we rank in this class the effects which they give by the reagents which are mixed with them, we do not pretend that these effects would be produced exactly in the same manner upon these matters if living. No modern chemist is guilty of this error; they all know, for example, that a high temperature does not act upon the parts or the liquids of living animals, as it acts upon those parts or those liquids after their death; that their organs and their fluids resist the action of the alkalies and the acids, as well as that of heat or cold, by the vital power which animates them. But they also know, that this resistance to the action of the chemical agents, is limited and acknowledges a certain boundary; that if we weaken the energy of those agents, even in their effect upon the dead animal matters, it becomes inert as upon the living, or, that by rendering it very strong in these, they then act as upon the dead matters. Finally, they do not apply these results immediately, and in all cases, to the living matters, but use them only as agents for ascertaining the composition of these matters.

11. Such are the general reflections, which ought to precede the applications of chemical knowledge to animal physiology; they are equally calculated to destroy the prejudices which have been propagated against the utility of these applications, and the abuses which have

have been made of chemistry in the explanation of the phenomena of physiology. I was obliged to unite them here as a sort of introduction to the animal chemistry, because they form the true foundation of the reasonings, which are at present employed upon this branch of chemistry; because they ought to direct our conceptions of the chemical phenomena which take place in physiology; and finally, because they prove that we cannot flatter ourselves with the hope of being able to comprehend what is permitted to man to attain in the mechanism of the animal economy, without the knowledge of the chemical properties of the fluids and solids which constitute it. In our present consideration of each function of the living animal bodies, the applications which I shall point out will develop these fundamental truths, and afford multiplied proofs of the indispensable influence, which the present state of chemistry must have upon animal physiology.

ARTICLE II.

*Of the Chemical Phenomena which take
place in Respiration.*

1. RESPIRATION, which, in the animal, is most complete, is exercised in the vesicular lungs, and is composed of the movements of inspiration and expiration, the most essential to life without which it could not exist; it is of those which have received the greatest benefit from the modern improvements in chemistry and knowledge. The hypotheses that had been imagined for determining its uses, from the earliest times down to the present time, have been false, which chemistry alone could correct, and have been substituted in their place; the truths, which chemistry alone could originate from the accurate knowledge that has been acquired respecting the air, and the means of analyzing this fluid, which the metaphysical doctrine alone could furnish.

2. It has been by experiments upon the animal, upon respiration itself, upon the air, from its entrance, and after its exit from the lungs, that the truths of which I speak have been discovered. Cygnus, Priestley, Crawford, and especially Lavoisier and

have successively instituted the researches which have led to their discovery. Venous and arterial blood exposed to different gases; animals inclosed in bell-glasses, with air in different circumstances; the examination of the air at different periods of these experiments; man himself, exposed with the aid of ingenious machines to the action of the air and various aerial mixtures: such are the principal means that have been employed for resolving the problem of respiration: and though there is still some doubt and uncertainty respecting the results of these experiments, they have, however, thrown upon this important function, a light which it could not derive from all the ancient data of physiology, without the instruments and means of modern chemistry.

3. It has been found that the air which enters the lungs is altered, and that the proportion of oxygen gas progressively diminishes in it; that animals, in a given time, do not consume more of the oxygen gas requisite to the support of their life, whether they be made to respire it alone, or whether it be mixed with azotic gas, in different proportions, provided it amount to at least a tenth of the mixture; that carbonic acid gas is formed during inspiration; that there is also produced a certain quantity of water, independent of that which is discharged immediately, and ready formed from the blood by the pulmonary transpiration; that when in respiration, by an external addition of this gas,

gas, the proportion of the carbonic acid amounts to $\frac{1}{4}$ of the air, the exercise of this function is accompanied with great inconvenience; that the quantity of azotic gas is neither greater nor smaller, but remains exactly the same in the air expired, as it was in the air inspired, and that this gas does not influence respiration: that the consumption of air in respiration increases after a meal, in lifting burthens, in performing any exercise, especially in running.

4. From these first effects which have been accurately determined by experiment, modern philosophers have concluded, that the oxygen gas is that principle of the air, which is useful in respiration, that it is there subservient to a combustion, that it burns carbonated hydrogen separated from the venous blood, that thus carbonic acid gas and water are formed; or rather, that the oxygen is absorbed by the blood and its place in the pulmonary air, supplied by carbonic acid and water; which, indeed, renders the problem undetermined. But if we remark that the venous blood exposed to oxygen gas, converts it into carbonic acid; that the combustion of the carbonated hydrogen in oxygen gas takes place in a multitude of vegetable or animal organic matters, even at very low temperatures, it will no longer appear doubtful, that this compound, which has become superabundant by the effect of the circulation, really burns in the lungs, and that the oxygen gas of the air combines in the pulmonary

pulmonary vesicles with those two principles, the hydrogen and the carbon, so as to form water and carbonic acid, which did not previously exist, either in the blood or in the air.

5. Though this conversion of the carbonated hydrogen of the blood, and this conversion of the atmospheric oxygen into water and carbonic acid, be the principal phenomena of respiration, there is no reason to doubt that a small portion of this vital fluid, is at the same time absorbed by the blood, and contributes, with the loss or the disengagement of the carbonated hydrogen, to change the nature and properties of this liquid. Thus, the undetermined problem of which I have spoken, is not really such, except with relation to the proportion of atmospheric oxygen absorbed, and to that of the same oxygen employed for burning the hydrogen and the carbon, for forming the water and the carbonic acid. It is probable that this proportion, this partition of the absorbed or burning oxygen, varies according to many circumstances, which shall be hereafter appreciated, and the knowledge of which, will give greater precision to that of the mechanism and uses of respiration.

6. From the combustion of the carbonated hydrogen, the principal phenomenon effected by the air during inspiration, result two important effects respecting the nature of the blood; and in these two effects consists one of the most important uses of respiration. The
blood

blood is deprived of a principle with which it was surcharged, and which rendered it unfit for the purposes of life; its nature is changed, and its composition renovated; so that it becomes susceptible of fulfilling the functions for which it is destined, as I shall show in the article concerning the circulation. On the other hand, the oxygen gas cannot burn the hydrogen and carbon of the blood, without being condensed, without losing or suffering a portion of the caloric which kept it dissolved to be disengaged, in the state of an elastic fluid; and this caloric having become free, seizes upon the blood, and elevates its temperature. That portion, also, of this gas, which is condensed in the blood, develops by its condensation, a portion of its caloric, which contributes to heat this liquid.

7. Thus, according to the first ideas of Crawford and Lavoisier, one of the principal utilities of respiration, and one of the most remarkable uses of the air received into the lungs, is the production of the animal heat: by the aid of the combustion which is effected in them, the blood becomes heated and maintained at the temperature which characterizes this liquid. The chemical explanation of what takes place in respiration, is entirely comprehended in the following proposition: The attraction of the carbonated hydrogen of the blood, and of the entire blood, for the oxygen, is stronger than the united attractions of the caloric for the oxygen,

oxygen, and of the carbonated hydrogen for the blood; the atmospheric oxygen gas is decomposed; its base unites with the hydrogen, and with the carbon, or is condensed in the blood, whilst its disengaged caloric combines with this liquid. The blood besides absorbs the caloric the more speedily, as in losing its carbonated hydrogen, its capacity for caloric is augmented, as shall be shown in the subsequent article.

8. These effects of respiration agree so well with the known phenomena of this function, that the comparison and combination of these phenomena give additional strength to the theory furnished by the modern experiments. The heat of animals is constant as long as their respiration follows the same laws. When the inspirations become more considerable, and more frequent by exercise, running, singing, exertion, the heat increases with the respiratory movements. In morbid debilities, when the spasm diminishes, and retards the inspirations, at the approaches of death, the body becomes cold in proportion as the respiration is concentrated or extinguished. The animals which respire little, or which do not respire air, like tortoises, frogs, serpents, fishes, have blood not sensibly heated above the temperature of the medium which they inhabit, on which account they are called *cold-blooded animals*.

ARTICLE III.

Of the Chemical Phenomena which take place in the Circulation.

1. THE cause and the effects of the circulation of the blood were equally unknown, previous to the new chemical discoveries; an obscurity pervaded this function, which appeared the more profound, and the more hopeless, as the organs by which it is carried on were very well known: every thing was therefore completed for anatomy, whilst every thing remained to be done for physiology. An equal ignorance prevailed, both of what produced the motion of the heart; of what distinguished the venous from the arterial blood, which was known to be different from it; of the changes which this liquor underwent in the arterial and venous circulation; of what happened to it by its mixture with the chyle, and the cause of the great influence which it has upon life, as well as upon all the other functions of the animal economy. Every thing appertaining to this primitive function, was a mystery that had been considered impenetrable. By chemistry alone, this part of physiology, which still appeared hopeless, began to acquire some real illustration a few years ago.

2. It

2. It was in studying the phenomena of respiration, that modern chemistry discovered several of those of the circulation which had escaped the researches of physiologists; it first occupied itself with the difference between the venous blood arrived at the cavities of the right side of the heart, and the arterial blood which comes from the lungs and enters the left cavities of the heart, a difference, respecting which, it might perhaps be permitted to Haller to start some doubt as an anatomist, notwithstanding the data collected by Galen, Lower, Schreiber, Willis, Swammerdam, Duverney, Verheyen, Schwenke, Lancisi, Mayow, Pitcairn, Severinus, Helvetius, Michelotti; a difference, which is not the less real, on account of its being sometimes not apparent to the eye, and which might be deduced from the mere nature of things, and the slightest consideration of the functions and organs. The brilliant red colour of the anterior blood, the violet, and almost black hue of the venous, the more elevated temperature, the greater lightness, the frothy state of the first, compared with these properties considered in the second, showed that this liquor acquired new characters in the lungs, and by the influence of the air; that it lost carbonated hydrogen, acquired caloric and oxygen, was actually changed in its nature, and in a manner constituted afresh for a new life.

3. These new properties, this change of nature, this loss of carbonated hydrogen replaced
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by caloric and oxygen, give a revived blood, the power of irritating the heart, and exciting its contraction, by which the vital movement is perpetuated. All these defects depend so much upon the air containing oxygen, that without its presence respiration is stopped, the blood remains black and venous, the heart ceases to move, and even loses its irritable power, so that life cannot again be recalled, as we see in prolonged asphyxias. Crawford, by his ingenious experiments, has given confirmation and precision to this fine result of the modern discoveries; he has proved that the capacity of the arterial blood for caloric, is to that of the venous, as 11,5 to 10, and that in proportion as the latter is, as it were, revived in the lungs, and loses its carbonated hydrogen, it acquires the property of more easily absorbing the matter of heat.

4. The effect the blood so manifestly produces upon the heart, that power which it excites in it, and at the same time imparts to it, of contracting itself, and propelling this liquid by its left ventricle, even to the extremities of the arteries, whilst it can scarce give to the thinner coats of the right ventricle, the power of sending it to the little distant pulmonary ramifications, that effect it also produces upon all the muscular fibres of the different regions. It conveys, together with heat and life, the stimulating and existing force into all the muscles. Intimately united with the chyle, which

which restores to it, as it is poured into it, near to the base of the heart, the matter which it has lost in circulating, it animalizes this product of digestion, which, on its part, neutralizes the too far advanced animalization of the blood; it mixes and combines intimately with it, it associates with itself a new proportion of principles, destined to supply the place of what escapes from it every where in all the organs through which it flows. In this combination of the blood with the chyle, it appears that the conversion of the saturated and white phosphate of iron, which the latter contains, into superoxygenated red phosphate of iron proceeds from the simultaneous double effect of the blood, of the soda, and of the oxygen of the air; the first as carrying off a portion of phosphoric acid, and insulating an excess of iron; the second as superoxidating and reddening the latter: so that it is by this chemical mechanism that the coloration of the blood is produced and exalted. Thus the relation of the co-operation of the effects of the circulation and the respiration upon the blood, constitute, in the point of view of the composition of this liquid, and by the different modifications which I have described, that result hitherto so incomprehensible, which the physiologists have designated by the name of *hæmatosis*.

5. Phenomena, in some sort the reverse, take place in the act of the circulation itself, and especially at the extremities of the arterial ramifications, at the boundaries of the circulating

system, and in all the places, and all the surfaces where these extreme ramifications terminate in the extremities of the venous branches. The arterial blood every where distributes heat, irritation, and life; it moreover transmits the albuminous or fibrous nutritive matter; it suffers a portion of water to exhale from its own substance; and gradually becomes surcharged with carbon and hydrogen. By this change of nature, a part of its specific caloric is evaporated; in the same proportion it loses its vital faculties; it dies in some sort, or at least becomes incapable of propagating life in the organs. The oxygen, more intimately adherent, and combined with its elements, giving them the concrescibility and plasticity which constitute its reparatory and nutritive quality, separates from it with the fluids which deposit themselves in the organs, or which escape into the absorbent system; modified in its composition, deprived in part of its principles, become old and weakened in its vivifying powers, it is necessary that it should return to the centre of the respiration and circulation, to the confluence of the reparative chyle, in order to resume all its original properties, and to recover by the effects which I have described, the equilibrium of combination, of aëration, of oxidation, and of temperature, which constitute it arterial blood.

ARTICLE IV.

*Chemical Phenomena which take place
in Digestion.*

DIGESTION, the function by which the
 s received into the stomach are con-
 into chyle destined to repair and renovate
 od, presents so considerable a series of
 al phenomena, that it appears to belong
 to the province of this science, and
 cannot be better conceived or better
 ed, than according to the principles
 mistry. Accordingly, it is of all the
 functions, that with which the chemists
 ost occupied themselves, that which they
 bjected to the most numerous expe-
 , and for the theory of which they have
 the most results. And in fact, since it
 consists in the appropriation of the
 ary substances, and in changes of nature
 a kind, that these substances become
 ble of replacing the portion of the
 and of the organs themselves which is
 tly destroyed by the vital movement,
 ossible to consider it as any other than a
 emical operation.

he aliments placed in the mouth, are first
 and mixed with the saliva; the division

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which

which they receive by the action of the teeth, introduces into them at all points, both the salival juices and the air, which this juice is susceptible of retaining, as is proved by its frothy property. From this attenuation, and this mixture result in the alimentary bolus, disposition to soften, to dissolve, and already to approach to the nature of alimentary matter. In deglutition, and along the course of the œsophagus through which this bolus passes, becomes penetrated with more animalized liquid with the juice of the œsophagus which always gives it the character of animalization. There are even animals, especially among the birds and the reptiles, in which the digestion of the aliments commences in the œsophagus: this case, however, is only observed in those species which have no organs of mastication, and which swallow their prey without dividing it. We frequently find in serpents, entire animals that have not yet descended into the stomach, and that are already greatly softened in that part of the œsophagus which contains them.

3. It is in the stomach that real digestion takes place. The experiments of Reaumur and Spallanzani have incontrovertibly proved, that the aliments are there dissolved by the gastric juice; that this juice has a very great solvent energy which acts upon all the organic matters, even the hardest, such as the horns and the bones; that the solution of the aliments which result from it, reduces them in some hours,

hours, three or four at latest, into a kind of semi-liquid homogeneous bouillie, sometimes slightly acid, most frequently sweet, and almost without taste, of a grey colour, and which is called *chyme*. It is known that the pressure of the muscular stomachs, the heat which constantly resides in them, their proper motion, or that of the contiguous parts, are merely auxiliary circumstances, which may indeed favour and accelerate the solution or the digestion of the aliments, but which are not capable of producing it of themselves. It is also known, according to the same experiments, that the gastric juice, is so antiseptic in its nature, that it preserves the animal matters that are immersed in it for a long time from every alteration, and that it has been employed with success as a topical anti-putrescent: it not only prevents all fermentation of the aliments in the stomach, but also corrects and destroys the first putrid alterations which exist in the animal nutriment.

4. Though nothing has been found by the analysis of the gastric juice, that can serve to explain, *a priori*, the remarkable effects which it produces in the digestion of the aliments; though the phosphates, the animal mucilage the muriates, the free acid which it commonly contains, are not sufficient to account for its properties, it is acknowledged that these are not only very energetic, as I have said, but even

even constantly acting; that they exert their powers at all times, and in all the circumstances of life, and even some hours after death; even the coats of the stomach themselves are not exempted from their dissolvent power. The celebrated Hunter has often found the stomach rendered very thin, worn, and almost perforated, in the parts where this juice had accumulated, and especially after long fasting, and in the bodies of persons who had died in consequence of long protracted diseases.

5. The digested aliments, reduced to bouillie, united with the gastric juice which has penetrated and dissolved them, arrived, with the aid of the natural movement which carries them from the cardia to the pylorus in the cavity of the first intestine, the duodenum, there meet with the pancreatic juice of the bile, which appears to me to act upon the chymous mass, in a manner that has hitherto been mistaken by the physiologists. It has been said, that the bile, like soap, serves to mix the alimentary oils and fats with water, and to reduce the whole to the state of a kind of emulsive liquor, which is called *chyle*. This cannot be its use, as there are so many aliments that contain neither fat nor oil, and so many animals that never take any such substance amongst their nutriment. It appears to me that the bile, united with the pancreatic juice, effects a real precipitation of the chymous substance; that it is
itself

itself decomposed in decomposing the latter ; that this decomposition consists in the separation of the sweet, white, milky, chylous liquor, which retains, with the most fluid part of the digested aliment, the alkaline and saline substance of the bile; and in a concentration of the thickest and least digested portion, mixed with the colouring and oily part of the bile, forming the matter that is to become excrement.

6. By the truly chemical mechanism, the fat portion of the bile flows, and the too great redundancy of hydrogenated animal matter is evacuated at the same time with the grosser, the the more solid and the least digested part of the aliments. The mass thus precipitated or decomposed, passes slowly through the intestinal canal, by the peristaltic motion natural to this viscus. In its passage it is pressed by the successive contraction of the muscular rings and fibres of the intestines; this pressure squeezes out from it the chylous liquid, which is taken up by the absorbent and chyliferous vessels; the mass, deprived, through all the length of the small intestines, of this fluid and mild part, is gradually exhausted of it, acquires more consistence and solidity, combines more intimately with the oily and colouring matter of the bile, becomes more or less powerfully altered, acquires a darker colour, and dries more and more in the large intestines, assumes the character of excrement, arrives at length at the rectum, the
sides

sides of which it stimulates in such a manner, as to produce the sensation which solicits its expulsion.

7. When this function is exercised in all its force, and unimpaired, no elastic fluid is disengaged in the stomach, and the first intestines; carbonic acid is formed only towards the lowest regions of the intestinal tube, and at the period when having descended into this part of the canal, the residue of the aliments already converted into real excrement, begins to experience, by its detention and heat, the first movements of the spontaneous and putrid decomposition of which it is susceptible. The gas which is developed in the stomach, the wind, the carbonated and sulphurated hydrogen gases which distend the intestines, and which are sometimes extremely fetid, depend only upon a troubled digestion, upon a feebleness and inertness in the quality, or a diminution in the quantity of the gastric juice, upon an alteration in the bile, circumstances which sometimes concur, to leave in the alimentary mass, the property of experiencing, instead of being converted into chyle, that fermentation peculiar to it, when the digestive liquors are not sufficiently strong, or not sufficiently abundant to overpower and stop its production. Accordingly these cases are accompanied with inflation of the abdomen, liquid acrid, fetid, diarrhoetic evacuations, and pains more or less acute.

8. The

1. The phenomena and results of digestion so far chemical, that they may be reduced to the action of a solvent liquid, and to the passage of the dissolved aliment into capillary vessels; accordingly, it is one of the functions, the apparatus of which is the least complicated, which requires only very simple organs, which receives but very little influence from, and does not require the concurrence of most of the other functions, which is constantly and easily executed in animals of the least complicated organization, even in those that are destitute of brain, of nerves, of heart, and of vessels. It corresponds in some measure with the simplicity of the effects which take place at the roots of plants. As being indispensable to the support of the body, and the life of animals, it is exercised with great facility; it escapes the action of many of the external causes and organs, though it is not entirely exempt from it in man, on account of the energy and sensibility of a great number of nervous filaments which envelope or are contiguous to the stomach.

ARTICLE V.

*Of the Chemical Phenomena which take place
in Secretion and Transpiration.*

1. SECRETION, or the separation of several different liquids from the blood, in different organs of the bodies of animals, is perhaps the function least known, though at the same time it is the most generally diffused. It is found in the vegetables, in which, in fact, it is not uncommon to see the sap give rise to peculiar and different juices in their different parts, in which some have even carried the analogy so far as to admit glands, and a glandular system. Physiologists have successively imagined several theories for explaining the nature of secretion; they are all more or less hypothetical or improbable. For the greater part they suppose the different animal fluids to be contained ready formed in the blood, so that, according to this opinion, secretion consists merely in their separation by the glands. Its mechanism is supposed to be explained by the difference in the diameter, length, and convolutions of the vessels, and even by the varieties in the forms of the holes, with which the glandular system is supposed to be perforated: hence the expressions of
strainers

strainers and filtres so frequently used in physiology.

2. It can no longer be admitted that the blood is a mixture of all the animal liquids, that it is formed of saliva, of bile, of gastric juice, of urine, &c. since the most exact analysis does not exhibit these liquids in it; and though all their compotent parts, as well as those of the solids are in fact contained in it, they exist there without being combined as they are in each of these bodies. The blood is manifestly a homogeneous liquor, of one general nature, but disposed to form all the animal matters, from the most transparent and least compounded liquid, such as the humour of the transpiration, to the hard and solid texture of the bones; it serves to constitute the saliva, the bile, the urine, as it serves to repair the muscular flesh, the membranes, the viscera; but these different matters are not all contained ready formed in it, and the secretion must not be confounded with a separation, or a filtration, as has been pretended.

3. As secretion cannot be considered as a mechanical operation, it must necessarily belong to the chemical phenomena; it must consist in a change of nature which the blood undergoes in every glandular or secretory organ: accordingly we see that in the vicinity of each of these organs or of the organic systems, the sanguineous vessels are disposed in such a manner as to permit the liquid which they contain to assume a peculiar nature, and to produce

duce there the modifications required by its composition. This is a preparatory disposition, a sort of appropriation, which has not escaped the notice of the most ingenious physiologists. In no part is this preparation more marked than in the vicinity of the liver or in the hepatic system; I have noticed it sufficiently in the article concerning the bile and the fat.

4. Analogy, the light of which is frequently the only guide which we can yet follow in physiology, necessarily induces us to believe that it must be with all the secretory organs, as with that of the bile; that the structure of the contiguous vessels or of those which penetrate them; that the number of these vessels itself, and the varied proportion of the red and the white ones; the difference of temperature which follows this proportion; in a word, all the circumstances of organisation which may influence the nature of the liquors of which they are the conductors, must be sufficiently diversified to produce, in the chemical elaboration of the humours, a disposition to become saliva in the vicinity of the salivary glands, urine in the neighbourhood of the kidneys, &c. It may be conceived that this disposition, dependent upon the vascular apparatus, consists especially in the retardation, the acceleration, the refrigeration, or the calcification of the blood; the loss or the absorption of some principles; that it is to this that the different nature of the blood

blood in the different regions of the body is to be attributed ; that thus the aërated blood of the superior parts seems disposed to form light, frothy, &c. liquors ; that the retarded and hidrogenated blood of the vena-porta already inclines towards the oily character of the bile, &c. &c.

5. As yet chemistry can furnish only generalities upon this subject ; and if it be understood that it belongs to the province of this science to explain the causes and the products of the secretions, it is necessary that it should be much farther advanced than it yet is, that it should possess much more numerous experiments, much more exact inquiries, and many more animal analyses than it yet does, in order to account for what passes in each particular species of secretion. It would be necessary to determine the temperature, the consistence, and the nature of the cerebral blood, those of the blood of the vena-porta, of the blood of the renal arteries, before the mechanism of the secretions which take place in the brain, in the liver, in the kidneys, can be comprehended. It will be no less necessary to acquire a better knowledge of the structure of the glands, and to carry this part of anatomy beyond the point at which it has arrived, in order to investigate what kind of influence the organization and the vascular texture exercise in the formation of the different fluids.

6. The

6. The secretion, considered in the way we have seen it in the four preceding numbers, greatly extends the limits of this function, since we must now define every change of nature in the blood, from whence the formation and separation of a liquid or solid animal matter results; whether this matter be destined to remain in the interior of the organs, or whether it be to be rejected out of the body. Thus, besides the secretion of the cerebral liquids, of the tears, of the nasal mucus, of the saliva, of the cerumen of the bronchic, gastric and pancreatic juices, of the bile, of the urine, of the transpiratory humour, of the liquid of the interior cavities, of the sperm, and of the milk, we must comprehend in this function the separation and the deposition in the different organs of the matters which constitute and repair them, of the albumen of the brain and nerves, of the gelatine of the membranes, of the fibrine of the muscles, of the calcareous and gelatinous phosphate of the bones.

7. Though most of these matters appear to be completely contained in the blood, yet their precipitation into the texture to which they belong, cannot be considered as a simple separation; since it is accompanied with a modification in the properties, in the nature, and the composition of each of these matters; since, as I have shown in the chemical history of each of them, the cerebral pulp is not exactly the same albuminous matter as that of the serum of the blood:

ood; the gelatine is not insulated in this fluid as in the membranous texture; the muscular fibrine has not a character absolutely identical with that which exists in the sanguineous fluid, and the phosphate of lime is not associated in the latter, with the gelatinous substance which connects its particles in the fleshy texture. Hence it follows that secretion always admits a change in its exercise, a certain modification in the matter which is its product.

8. Amongst the different kinds of secretion, there are few which have so many direct relations with the chemical phenomena as the transpiration, on account of the air which receives the product, and of the contact of this fluid which is necessary to its support. Though many researches still remain to be made upon this question, upon the quantity and nature of the liquid which is discharged from the skin, upon the variations which it experiences, upon the kind of influence which it receives, from the interior of the animated body and the state of the organs, modern chemistry has already found, in its no less exact than ingenious theories, results capable of causing a change in the opinions of the physiologists and physicians respecting the transpiration; they are chiefly to be ascribed to the experiments made in conjunction by Lavoisier and Citizen Berthollet. These results, indeed, relate only to the action of the air, which has hitherto been very little

little known, or very inaccurately studied, and respecting which Sanctorius, Dodart, Keil, Bryan Robinson, J. Rye, Gorter, Linings, and Hartman, notwithstanding their numerous experiments, had only imperfect notions, or rather erroneous and false ideas.

9. The transpiration with respect to the cutaneous surface by which it takes place, is only the evaporation of a fluid, in a great measure aqueous, which is effected by virtue of the attraction exercised by the air upon this fluid. There is no transpiration without the contact of the air, which is its solvent. When it is regular and complete, it is at the same time insensible, as the fluid exhales dissolved into vapour in the air, which is its necessary excipient. The sweat is only the excess of the transpiration which the air cannot dissolve. In a part of the skin, that is well covered and entirely defended against the contact of the air, there is no transpiration; but the liquid which the force of the heart-propels to the extremities of the arteries, accumulates upon the skin in more or less abundant drops. The cloths oppose the vaporisation of the insensible transpiration only partially, as they admit more or less of the access of the air. The transpiratory humour may be collected in oil-skin bags covered with elastic-gum and applied to the two extremities of a limb in such a manner as to intercept all communication with the air. Thus Citizen Seguin, in the experiments

periments which he made with Lavoisier, by girdling to himself a large silk bag, which closely enveloped his whole body, and was solidly tied round his mouth, found the means of exactly measuring what he lost by the skin, by the weight of his body thus inclosed, compared with that which it had in the air during the same space of time; and likewise of determining the proportion of water which passes off from the lungs, as well as the relations of these actions with the state of the body.

10. It follows from this first datum, that the drier and hotter the air is, the more abundant is insensible transpiration must be; that the more or less rapid motion of the air has a great influence upon this function, as upon an evaporation; that air saturated with water, entirely annihilates it, as though the body of the animal is immersed in water; that when the vital force which impels the humours from the centre towards the circumference, and which is the primary cause of the transpiration, is remarkably diminished, the air, supposing it to be very dry and of a great solvent power, may penetrate to the pores of the skin, and there dissolve the humidity, which will occasion its desiccation, takes place in bodies deprived of life, skins, and woods, which dry at their surface, towards which the water is gradually carried as in capillary tubes; that in the cases where the vital impulse of the liquids is greater than the solvent quality of the air, liquid drops or

VOL. X. N n sweat,

sweat, are formed upon the skin; that if the air found always on the elevation of its temperature wherewithal to saturate itself proportionably with water, it would never augment the insensible transpiration; that should it go so far as to elevate itself above the human temperature; and at the same time saturate itself with water, it would rather deposit drops of water upon the skin than dissolve any.

11. All these considerations respecting the air, as a solvent of the matter of transpiration, lead us to several results different from those which have hitherto been advanced upon this function: such is that especially of the cold air dissolving water at the surface of the body, and favouring transpiration more than hot air. In fact, the air at 0 of temperature, and little charged with humidity, becomes heated, when it touches the skin, and by thirty two times a more powerful solvent of the water; so that at this temperature our bodies lose more than in the hot season. This augments greatly if the cold temperature of the air is joined with a considerable motion, or agitation which frequently renovates its mass or solvent stratum. Accordingly, in cold and windy weather, the transpiration is, *ceteris paribus*, at its *maximum*, this is what then renders the skin dry, and as it were scaly; while in the summer, especially when the air is humid, the skin is moist and the members swelled. Thus the agitation

by exactly covering the skin, they almost completely interrupt the contact of the air, and prevent the solution of the water by this fluid, which they are not capable of absorbing. On the same account, the use of woollen stuffs worn upon the skin is useful in some cases, from the obstacle which they oppose to the transpiration rather than from the augmentation of this excretion which has nevertheless been always attributed to it: this proves that the affections in which this kind of clothing is of service do not proceed, as has been believed, from suppressed transpiration, but rather from excess or irregularity in this cutaneous evacuation. When we wish to favour the discharge of the transpiratory humour by the choice of clothes, we ought to take those of linen or cotton stuffs, which having a great attraction for water, soon imbibe and become impregnated with it; they must be frequently changed in order in some sort to replace the air, which does not immediately touch the skin.

15. The animals whose bodies are covered with hair must transpire much and sweat little; because the humour of the transpiration, diffused over the whole continuity of the hairs, and thus presenting a surface perhaps a thousand times greater than the skin, is much more quickly taken up and dissolved by the air, than would be the case if it remained upon the surface of the latter. Besides, the air insinuating itself between the hair, becomes more heated than
by

by the mere contact of the skin, on account of the larger surface which it touches, and thus becoming a better solvent of water, it must take up a much larger quantity than from animals with a naked skin. It is undoubtedly owing to this circumstance that several of the mammalia have been said never to sweat.

There are still many curious inquiries to make relative to this subject, among the various classes and genera of animals.

ARTICLE VI.

Of the Chemical Phenomena which take place in Nutrition.

1. NUTRITION presents great difficulties to the physiologist. It is not only very difficult to determine how a primitive homogeneous liquid, the blood, contains all the different materials proper for constituting the different parts of the body; but it is still more so to know how the various liquids which emanate from it are converted into solid matters which incessantly attaching themselves to the organized textures of which the viscera and the parts of the body are composed, perpetually renovate the mass, and thus repair the losses which are occasioned by the vital movements.

2. The problem of nutrition is composed of two other problems equally important and difficult to be resolved. The object of the first is

is to determine how the organs or solid parts augment in extent and weight during a certain period of the life of animals consecrated to their growth; and why this growth stops at a certain period; the second relates to what takes place after growth, and in maintaining the organs in the same state of extent, of form, of weight, and especially of vital powers, or to the uninterrupted reparation of the parts which are destroyed by the action itself which they exert.

3. In order to explain the phenomenon of growth, it has been supposed, that the organs were originally formed of parts susceptible of great extension, of cells or laminæ united or folded together, which receiving into their pores or at their surfaces the nourishment which is applied to them by the work of nutrition, become elongated, extended, and unfolded to a determinate magnitude according to the species of the animal, and the developement, or of which extension does not cease till the period when they can no longer yield to the elongation; it was necessary also in this theory, to suppose a determinate primitive form in the organs, and to consider these as kinds of moulds upon which the animal matter applies itself at all points.

4. What belongs to the province of chemistry in this first part of the problem of nutrition, is the rapid and easy formation of all the different compounds which are destined to enlarge each of the organs of the body: and first, the very

very considerable digestive power; the quantity and solvent energy of the gastric juice, which producing a more frequent and greater appetite or hunger, requires a more ample accumulation of aliments in the stomach; a more rapid effect of the hematosis by the more frequent respiration and circulation; a more speedy renovation of the blood, as well as a more easy and quick separation of the different materials, which constitute it in the organic regions to which it gives life; a more powerful attraction of each texture for the matter appropriate to it, and which is conveyed to it in greater abundance and with greater celerity than in the other periods of life; finally, a more accelerated and more powerful concrescibility in the nutritious humour, accompanied however with an energetic absorbent power in the whole system of white vessels.

5. As to the common or simple maintenance of the organs after the end of growth and till that of life, it is performed by the same mechanism; it admits the same chemical phenomena; it supposes the uninterrupted consequence of the assimilating power, and only shews it diminished in its energy, and gradually losing, till old age, a part of its force. In order to account for the transition of the nutrient liquids into the solid and organic state, physiologists have admitted with the ancients, a plastic power, or a general concrescible property, which has appeared to them sufficient for the explanation

planation of this phenomenon. The modern chemists, who have advanced a little farther than had been done before them in seeking into the cause and the nature of this concrescibility, now show now that it proceeds from the combination of oxygen, and that it is on this account that the animal liquors have so much disposition to absorb this principle.

Though nothing is yet known respecting the particular nutrition of each organ, or respecting the influence exerted upon it, both by the medium which surrounds it and that of the organic texture itself, we see that this function, considered generally, supposes a complete assimilation, an entire change of primitive elementary matter into each particular organic substance; that this assimilation, commenced in digestion, continued in respiration, most completed in the different stages of the circulation, and entirely terminated at its entrance to each organ to be nourished, principally consists in the loss of the carbon and hydrogen, the augmentation of the azote, and in a sort of transmutation which has hitherto been named animalization. Notwithstanding the varied textures which the textures of the different organs appear to present, we may class them into three or four matters, as I have several times said; namely, the gelatin, which forms the basis of the membranous textures; the albumen, which constitutes that of the brain, of the nerves, and of the parenchyma of the viscera; the
fibrine

fibrine which composes the muscular fibres, and the gelatiniferous phosphate of lime, which belongs to the bones,

ARTICLE VII.

Of the Chemical Phenomena which take place in Irritability.

1. NEARLY forty years have elapsed since the physiologists first perceived some relations between the irritable force of the muscular fibres, and the chemical powers; because since the experiments of Haller, they have observed that the acrids, the acids, the alkalies, the metallic salts, have the power of exciting, by the slightest contact, the contraction of these fibres; and they have even derived from this effect the appellation of irritability, which has been given to this function, which, whilst it presents the most strongly marked characters of animated bodies, has appeared involved, with respect to its cause and effects in insurmountable difficulties. The immediate conclusion which had been drawn from the action of acrid and irritating substances upon the contractile muscular property, was formerly confined to the supposition, that the will and vital power conveyed into the muscles,

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in order to cause their motion, a stimulus capable of exciting their contraction, as was done by any extraneous acrid body, with which they were touched.

2. The discovery of Galvani, and the labours of many modern physiologists, especially of Mr. Humboldt, upon this discovery, have shewn that the chemical properties have great influence upon the exercise of the irritable power of the muscles, and that the action which takes place during their contraction between the nervous pulp, and the muscular fibre, has essential relations with the phenomena that belong to the province of chemistry. Different metals, the one touching a nerve, and the other a muscle, or attached on each side to these nerves, by the name of *armatures*, and a communication being afterwards by means of a metallic branch, excite a more or less violent convulsion in the muscles of an animal recently killed. The mere immediate contact of a muscle and a nerve, both laid bare, produces the same effect. A similar one is made to take place upon living animals; frequently these experiments, applied to different parts of the mouth and of the face, or of the intestinal tube, give rise to sensations of smell, of taste, of pain, of heat, of vision, and even to augmented secretions or evacuations. The modern works upon galvanism, or the metallic irritation, are replete with facts that prove these assertions.

3. Many

3. Many philosophers believe that the phenomena of galvanism depend upon electricity, and proceed from the electric fluid; this is especially the opinion of the celebrated Professor Volta; however, Mr. Humboldt has found bodies which, without being conductors of electricity, are such of galvanism. But, even supposing that ulterior researches might convince all philosophers that these two phenomena proceed from the same cause, galvanism would nevertheless be referable to a chemical effect, as there manifestly exists such a one in electricity. In order to conceive this connection between the galvanic phenomenon, and those which depend upon chemical powers, we must admit vaporous atmospheres, more or less thin at the surfaces of all bodies, and especially those of metals; the smell which they exhale to a certain distance, the oxidation frequently very prompt which they undergo, when they are placed one upon the other under water, evidently prove the existence of these atmospheres, and the chemical action to which they are subject.

4. With this first datum, it is impossible to deny a chemical effect in the galvanic phenomenon, and consequently in the muscular contraction, or the exercise of the irritability of the muscles. Even the manner in which this irritability, or susceptibility of the muscles to the galvanic irritation, is weakened or augmented in which it is checked, or its duration prolonged, by the aid of chemical powers, or
different

different re-agents, farther proves its intimate relation with the laws of chemistry; but of what nature is the chemical act, the kind of combination or of decomposition which takes place in the muscle or in the nerve, or in both at once, at the moment when the muscular contraction is performed; and how are the shortening and the swelling of the fibre its consequence? All this is still a problem, which can only be solved in imagination, since experiment has not yet been able to teach us any thing respecting this subject. It only appears sufficiently certain that this effect of the decomposing or recomposing attractions does not sensibly change the nature of the muscle and of the nerve, and that the cause which gives rise to this effect, is changeable, moveable, and in some sort accessory to the muscular fibre, since the effect diminishes or augments the activity, promptitude, and force; since the fibre experiences fatigue under it, and requires a restoration which is procured to it by repose.

5. There is reason to believe, that it is at the point of contact between the nerve and the muscular fibre that this takes place, that it is between two substances existing in these two organic textures that it is exercised; that the nerve brings, by the action of the will or any stimulus, the matter which gives rise to it; that this is what has been called the nervous fluid, or the animal spirits; that the contraction consists in this reaction itself between the two textures; that the chemical action having taken place, and the
state

state of the bodies changing by this chemical effect, are the causes which renders it so rapid, and which so soon bring about its cessation; as well as the relaxation of the fibres which is its consequence; that it is on this account that the voluntary effort of a continued contraction requires a considerable force, of which lassitude and pain are the necessary consequences. It is also evident, according to this theory, that all the movements in the animal economy, dependent upon muscular irritability must be intermittent, or marked by successive periods of activity and repose; that the heart, being the most energetic, the most vigorous, and the most independent of all the muscles, must have a more abundant and more frequently renewed source of irritability and motion than all the others, as appears from the considerable quantity of blood which it receives, and of nerves which are dispersed through its texture.

ARTICLE VIII.

Of the Chemical Phenomena which take place in Sensibility.

1. IRRITABILITY presents to the philosopher but very few applications of chemistry, though it may be perceived that its cause and its effects are subject to the chemical attractions,

or at least are much accompanied by them, as appears from the galvanic experiments. Sensibility is still more abstruse in its mechanism, and in its source. The theory of this function is covered with the most impenetrable veil; it is a mystery, the depth of which no human mind has yet been enabled to fathom. The most minute dissections, the most multiplied experiments, phenomena the best described, and the best compared by physicians, who have so many opportunities for observing all the circumstances which sensibility, weakened or exalted, modified or altered by diseases, can present, have as yet hardly ascertained any thing respecting this function.

2. It is also this part of physiology which has given the most occasion to conjectures; in which the imagination has the most gone astray. The mechanism of the sensations, the relation of the nerves with the object felt at the surface of the body, and with the centre in which the sensation is united, are as obscure as they have always been, notwithstanding all the facts which have been collected for many centuries past. What are called the internal senses: Those functions which are generally referred to the brain, such as the memory and the imagination, are still more difficult to comprehend, than the external sensations. Pleasure and pain, desire, the will, all the passions which have their seat in the cerebral labyrinth, and their ministers in the nervous filaments, distributed throughout

throughout all the organs of sensation and motion, are so many problems, whose solution is the most remote from the results that may be expected from the progress of the sciences. It is besides on account of the immense chasm which the study of the mechanism of this function leaves in animal physiology, that we are led to consider the science of the organized and living bodies, as much above the common physical sciences; or as a science entirely different, and of a quite peculiar nature.

3. As it is impossible that these functions should be exercised by the intervention of the solids alone, or that the fluids should not be the most active of the instruments which nature has appropriated to their exercise, in conformity with the fictions of the animal spirits, the vital spirits, the nervous fluid, it was believed, from the close analogy with the known data of physics, that they ought to be ascribed to the electric, the magnetic fluid. Of late, recourse has been had to a particular fluid, called the galvanic, from the discovery of the Italian physician, of whom I have just spoken, and because remarkable differences have been observed between the progress of electricity, and that of galvanism. It must, however, be allowed, notwithstanding these more ingenious approximations, that no satisfactory explanation has yet been found of the mechanism itself, of the function of the brain and of the nerves, particularly in their relation

elation to the internal senses, especially of what appertains to the internal senses.

4. M. Humboldt believed he might hazard conjecture respecting the chemical function of the brain, both with respect to the fluid which is conveyed into it to nourish and vivify it, and to its action relative to sensibility and irritability. He imagined that the blood conveyed into the cranium by the carotid and vertebral arteries, transmitted immediately from the left cavities of the heart, after having been renovated in the lungs, arrived in the brain, charged with a large quantity of oxygen; that a part of it was speedily deposited in the pulp of this viscus, and that it was to this principle, thus accumulated or deposited, that the cerebral substance might owe its principal properties.

5. But though this notion seems to accord with what I have said elsewhere, respecting the luminous nature, the concrete and manifestly highly oxygenated state of the albuminous cerebral mass, yet how far distant is this first idea from a satisfactory explanation of the actions of the brain and nerves? How can we admit oxygen as a fluid sufficiently rare, light and rapid in its motion, to be substituted in place of the electric, magnetic, and galvanic fluid? How conceive that this liquid or gaseous body can pass through a pulpy texture, through full and solid ligaments, in which it has hitherto been impossible to discover the least trace of canal

or cavity? Can it be supposed with probability, that the cerebral and nervous medulla has the property of successively saturating itself with oxygen, and absorbing it from its origin in the same proportion as it escapes, or is exhausted at its sentient or moving extremity, so that the integrity of the sensitive organ should consist in this constant state, in this permanent equilibrium of the oxygenation of this organ, incessantly nourished by the oxygenated blood which arrives in it immediately as it issues from the pulmonary apparatus?

6. Let us admit that nothing is as yet more incomprehensible, that no mystery is more impenetrable, than what appertains to the functions of the brain and nerves, in the exercise of sensibility and mobility, and especially in that of the internal senses. Let us acknowledge that no datum yet leads to the solution of this sublime problem, so remote in its essence, as well as in its cause, from all the other parts of natural philosophy. Well convinced that all that has hitherto been said respecting this subject, belongs only to the reveries or conjectures of the imagination, we may nevertheless maintain, that though as yet not very successful, the efforts of modern chemistry seem to deviate less from the truth, than the mechanical or physical explanations that have heretofore been given, and that if it may be permitted to the human mind to hope for some insight into these functions, hitherto so superior to its comprehension,

ension, it will receive greater aid in these researches from the chemical powers, than from the different means that have been employed for obtaining it.

ARTICLE IX.

Of the Chemical Phenomena that take place in Generation.

1. **THOUGH** the phenomenon of generation enveloped in almost the same obscurity as that of sensibility, though this reparative and conservative function of the human species has always appeared to philosophers to be covered with a veil of mystery, the experiments of the present age, have, however, begun to draw aside this veil, or at least to diminish the darkness in which it is involved. If its profundity is not yet been fathomed, prejudices which its antiquity had rendered respectable have, at last, been destroyed, and some principal facts discovered, the application of which, to the phenomena already known, has become a new source of prolific truths.

2. We have shown in the history of the spermatic liquor, and in that of the liquor of the testis, that chemistry is not entirely useless in researches relative to generation. To have

ascertained with exactness the nature of the fecundating liquor which gives the first movement of life to the organic rudiments in the maternal ovum, is to have made a step farther in the history of this function. It is true, this knowledge has not yet thrown any light upon the mechanism of fecundation, neither do we see in the mucilage, or in the phosphate of lime, and soda of the sperm, the source, or the cause of this wonderful property which communicates the vital movement. It is not less certain that we see no relation between the most accurate analysis of the eggs or of the sperm, and the extraordinary, and as it were, inexhaustible power of the latter, which uniformly communicates its fecundating property, to several thousand times its weight of water.

3. But let us not conclude from the hitherto insurmountable difficulties which the history of generation presents, that they must ever remain insurmountable. Let us not lose our courage, nor relinquish our hopes; let us consider, that almost nothing has yet been done in comparison with what remains to be done; that only one chemist has yet examined the seminal liquor of a single species; that this examination must be pursued in the different classes of animals, especially in the most prolific, compared with those that are least so. Let us hope that at some future period, an unexpected discovery may point out a road hitherto unknown to physiology, and let us not relinquish the idea, that

that chemical experiments applied to matters peculiar to the fœtus, and hitherto completely unknown, may lead to some new truth, the existence of which, no mode of physiological research has yet led us to suspect.

ARTICLE X.

Of the Chemical Phenomena which take place in Ossification.

1. OSSIFICATION, or the maintenance and formation of the bones, is the function which has received the most light from the knowledge and discoveries of chemistry. The osseous texture, composed of a thickened gelatinous mucilage which forms its organic parenchyma, and of phosphate of lime deposited in the areolæ of the former, either in the form of grains, or of fibrous filaments, or in the state of imbricated laminæ, has been well ascertained, only by the labours of the modern chemists. The action of water, and of the alkaline or saline leys, upon the gelatinous body which they dissolve; that of the acids, which, by carrying off the phosphate of lime before the gelatin, soften the bones, and render them at the same time transparent and cartilaginous; calcination, which, by decomposing and destroying the gelatinous substance,

substance, insulates the phosphate of lime, if it has continued for a sufficient length of time; the lixiviation of these bones calcined to whiteness, which, by separating some portions of muriate and carbonate of soda, contributes still more to purify the phosphate of lime, of which their base is composed: these different analytical operations have left nothing more to be desired, respecting the nature of these solid organs.

2. The composition of the bones, once well determined, it was no longer difficult to comprehend the mechanism of their formation, which is called *osteogeny*. The bones of the foetus, immediately after it has left the egg, or the womb, are a kind of soft and transparent membranes, in the duplicature of which, the phosphate of lime deposits itself, and fills the areolæ. This earthy salt is not precipitated alone and pure, as is proved by the calculous concretions of the bladder, and the other regions, in which we find the insoluble phosphate combined with a gelatinous matter. The rapid formation of the bones in the first periods of life is explained by the superabundance of the phosphate of lime, owing either to the nourishment, or to the non-evacuation of this salt, of which the human urine is destitute at this age.

3. There is no doubt that the calcareous phosphate is conveyed into the bones by the sanguineous liquid, which penetrates into them by vessels sufficiently numerous, to render their colour reddish in newly born animals, and in the
the

the analysis of which we find this earthy salt. The chyle incessantly pours the osseous materials into the blood, since the phosphate of lime exists in all the aliments, and especially in the farinaceous vegetables, or in the animal matters. The examination of the farina of wheat, has proved to Citizen Vauquelin and myself, that man takes every day between three or four grammes of calcareous phosphate, in the quantity of bread which forms the most abundant part of his nourishment, and that this salt is generally one of the most constant, and most common insoluble and fixed matters, in the insipid, and as it were, earthy residues of the vegetable and animal substances.

4. When the primitive membranous parenchyma of the bones of the human foetus, is sufficiently charged by the deposition of the gelatinous calcareous phosphate; when the first work of ossification is sufficiently advanced, for the bones to be well formed, solid, and capable of resisting the action of the muscles, so as not to be bent by their different motions, the excess of insoluble phosphate is conveyed into some particular regions; the teeth become hard, elongated, and protruded from their alveolæ; the urine evacuates the superabundance of this salt, which it did not contain previous to this period. In the mammalia, in which this liquid contains little or no phosphate, it deposits itself in the hair which covers the body; in the horny substance which terminates

minates their extremities ; in the corneous appendages with which their heads are provided, or else it passes off by the skin, with their transpiratory humour, and is every where accompanied with the gelatinous substance, with which it is constantly found mixed in the animal body.

5. If by any cause, the natural evacuant of the redundance of calcareous phosphate, does not employ itself in the proper proportion, the substance is disposed to concretion, and is conveyed into a multitude of places where it is deposited: this is what happens in advanced age, when the bones, furcharged with earthy phosphate, become brittle, when this salt is deposited in the tendons, in the vascular sides, at first towards the extremities, the motions of which become slow and difficult, afterwards, and gradually, from these extremities towards the centre, and even in the large vessels of the base of the heart. Thus, the sesamoid bones are first formed, towards the extremities of the tendons of the fingers, of the ligaments, of the capsular membranes, or towards the articulations, and afterwards the osseous concretions which take the place of the soft and membranous sides of the veins and arteries. Thus, in the prolonged existence of man, and of animals, gradually originates the cause of natural death from old age, of which the slowness in the motions is the necessary source, and of which the superabundance and deviation of the calcareous phosphate is a preliminary symptom.

ARTICLE XI.

Of the Variations which take place in the Chemical Phenomena of Life, according to the different Structure and Nature of the Animals.

1. I HAVE hitherto indicated the chemical phenomena which take place in the animal body, only in their greatest generality, and have considered them more especially in man, as the most perfect type of animality. Though there is a great analogy, in a chemical point of view, between the effects which take place in all animals; and though what has been stated in the ten preceding articles, may serve to explain what takes place in the different orders of beings which enjoy animal life, it is necessary that I should here point out the principal varieties, which these chemical phenomena exhibit, or at least the most striking differences that rise from the varied structure, and different modes of vitality of animals.

2. The variations in the structure of the principal organs of life, especially in those of respiration and circulation, produce in animals, modes of existence and of action, more or less different, as appears from anatomical and phyfological

physiological researches. Those which respire air by the lungs or by stigmata, and those which only introduce or receive water into their respiratory organs, must present, and in fact do present very different results in the exercise of this function itself, in the products which it gives, and consequently in many of the other phenomena of life. As the effect of respiration is in general a very manifest chemical action, this action must be different according to the mode itself, in which respiration is performed.

3. From this source, especially proceed the most remarkable differences of the chemical phenomena, which exist in animals; the air introduced into the respiratory organ, of whatever nature it may be, serves to absorb the superabundant hydrogen, and carbon, as well as to precipitate oxygen into the humours; from these two actions result the animalization, the vivification, the equilibrium of composition of the humours, and consequently, as we have seen above, the muscular irritation, motion, life, assimilation, and nutrition. What differences must arise from variations of this primitive effect, in the different orders of animals, from the birds which absorb the most air and oxygen, which have the most strength, activity, and life, in proportion to their mass, to the cartilaginous fishes, which, admitting only muddy and slightly aerated water into their fixed gills, have scarcely any means of evacuating the hydrogen and carbon? Is it not evident, that

from this difference proceeds the excessive mobility of the first of these animals, and the slowness of motion, and soft oily state of the flesh of the second?

4. How many other differences might be deduced from this primitive source, were all the varieties presented by the respiratory organ, and the influence of the air and the oxygen respired, profoundly examined in all the orders of animals. How many results, prolific with consequences no less new than useful, would be afforded by a well-made comparison, between all animals, relative to the quantity and the nature of the air which they respire, to the state of this fluid at its exit from their organs, and to the proportion of water and carbonic acid which they form. It is already known that they all attract the air in the same manner, that they all form carbonic acid in it, and absorb oxygen from it; but from a comparison of the proportion of air which they require; of the quantity of acid which they yield, relatively to their weight, and the surface of their respiratory organ; with their irritable power, their muscular strength, their digestive energy, and especially with their insensible transpiration, how many important data for animal physiology might be collected? I can here only sketch a mere outline, of all the resources which chemistry promises; I only wish to show the possibility of acquiring a large stock of valuable knowledge, by experiments

riments which it is now in the power of the art to bring to perfection.

5. What I have just announced with respect to the diversity of the chemical effects by the air in respiration, relatively to the difference of structure in the animals, may be applied to all the other functions. Even were it not confirmed by observation, it would be proved *a priori*, by the consideration of the necessary relations established by nature between these two primordial functions, this principle of life, the circulation, and the respiration, and all the other functions which are in many respects only their necessary consequences. In this manner Lavoisier and Seguin have been conducted in their ingenious researches from the experiments upon respiration, to those upon the functions of the skin and stomach. In fact, digestion, which renews incessantly the mass of the blood, must correspond with the rapidity of the motion of this liquid, and the loss which it sustains in the lungs; the transpiration which evaporates a large quantity of water, and which, by this evaporation itself, carries off a portion of the caloric, absorbed by the pulmonary blood, must follow the pulmonary and circulatory motions, in the products whose equilibrium it is destined to establish and maintain. All the secretions correspond in the same manner with the laws of these *prima mobilia* of life; the extent and force of the movements, the weakness or energy

of the senses, the rapidity or slowness of nutrition, even the duration of life, are subject to their direct influence.

6. If to this notion, which is already rendered a striking truth, by the reasoning upon which it is founded we join the observation of what takes place in the different orders of animals compared with each other, under the new relation of the chemical phenomena, which they present in the exercise of their life, we shall see that it confirms what has just been set forth. Thus we find that the reptiles and fishes, which respire but little, or which do not respire air, which have not blood of a temperature constantly more elevated than that of the medium which they inhabit, which absorb but very little oxygen, have at the same time very little or no respiration, and suffer no loss by their skin, which is covered with solid scales close to each other. We shall find them possessed of little sensibility, and an irritability which is tenacious in its duration, only because it is weak and little exhausted by stimulants. We at the same time find in them soft and glairy flesh, abundance of oil and liquid fat, a very slow growth, a prolongation of life on account of its little activity, scanty, rare, or frequently interrupted secretions, a tendency to repose or fattening, a slow restoration, &c.

7. This observation relative to the chemical nature of the organs, presents as its result,

two

two general classes of animals, proceeding originally from the contact and absorption of the air being very considerable in the one, and very feeble in the other.

The first, which are constantly immersed in the atmosphere, which incessantly renovate the air around them by very rapid changes of position, have highly oxygenated, highly concretisable, much heated, and very irritating humours; solid, moveable, irritable hot organs; they are very active in their functions, and require to be perpetually renovated: man, the mammalia, birds, and many insects, are in this order.

The second, concealed in the earth, or in subterraneous cavities; or in the midst of the waters; capable of living without air, or without a renovation of it; having frequently an intermittent respiration; remarkable at the same time by the slowness of all their motions, and by the little elevation of their temperature, as well as by the paucity of their evacuations, present, in their liquids, compounds, furcharged with hydrogen and azote, and but little oxygenated in comparison with the preceding. The reptiles, serpents, fishes; and many of the testacea, belong to this class.

8. Every thing must vary, and actually does vary in these two orders of animals, as is proved by their anatomical inspection, and their chemical analysis, and by the study of their functions, or their physiology. Each of the phenomena which they present, depending upon
this

is first difference of nature, and of composition, have, in the exercise of their life, varieties dependent upon the same cause. To this difference we must particularly refer the glairy mours, the viscous and insipid mucilages, which are so frequently and so abundantly discharged from the bodies of cold-blooded animals, and which we do not see produced by those animals which respire much air; from the same source arise both the abundant nourishment, the frequently renewed hunger of the latter, and the little aliment and possibility of existing without it for a long time, which is observed in the former. On account of the same imitative difference, the bones also do not require the same hardness in the little-oxygenated animals,—as they do in those which absorb much air. The skeleton of the first is either cartilaginous or excessively porous; less phosphate of lime, and much gelatinous matter is found in them; there are also both without and within the bodies of cold-blooded animals, any particular oily substances which are not found in the hot-blooded animals.

9. I shall not pursue farther, the differences which exist between the chemical phenomena, in the different orders of animals; I only wished to present a simple indication of these differences, in order to show, that they correspond with those of the structure, and that these establishing different relations, between the living animals, and the media which they inhabit, variations must ensue in the products which are
in

in many respects their results. It may be judged from this single idea, how many discoveries remain to be made in this line of chemical researches, and what improvements the science of animal physics may hope from it.

ARTICLE. XII.

Of the Chemical Phenomena which take place in Diseases.

1. IT has long been admitted by physicians, that chemical phenomena exist in the diseases which attack men and animals; that their humours undergo changes of nature more or less marked, and even that these changes are frequently the true causes of the morbid affections. Since the systems of the last century, which have retarded the progress of the art, by the injury which they have done it, and in which medical chemists were too hasty and too bold, and consequently formed dangerous applications of their opinions to the nature of diseases; wiser physiologists, confining the chemical theory to just bounds, have rendered great service to medicine, and have perceived in how far chemistry might be of advantage, and in how far it might be detrimental to it.

2. Thus

2. Thus Boerhaave, one of the most enlightened men in all the sciences applicable to the art of healing, has pointed out diseases proceeding from a glutinous humour, and others owing to a spontaneous acidity; thus he has directed the treatment of a great number of affections, according to the chemical characters of the alteration of which the humours and solids of the human body are susceptible, by comparing them with the opposite properties of the remedies. Thus, also, he has given precepts of great utility respecting the treatment of poisons and acrid bodies. Well acquainted with the mischief which had been done by means of chemistry before his time, and with the abuses to which it had given rise with respect to the employment of curative means, he was enabled to steer clear of the rock upon which so many others had struck before him, and usefully to employ those profitable applications which the one of these sciences constantly presents to the other.

3. Chemistry, advanced much farther since his time, enriched with a multitude of important discoveries, and proceeding with a much more steady course in her new theory, has resolved, during the last twenty years, many problems relative to the pathological state of the liquids and solids. It is now known that inflammation does not consist in a concretion of the blood, but that it is accompanied with a con-crescible disposition in the albumen and fibrine, which manifestly depends upon the greater degree

6. The theory which I have just enunciated, embraces in its generality a very considerable number of diseases; but it may be applied to all, or extended sufficiently by analogies to form an entire doctrine of pathology. Can we establish upon this first notion, however well-founded it may appear, for determining two classes of morbid affections, an entire system of nosology, or rather of pathologic ethiology? Ought we, with some modern authors, to classify all diseases into hydrogenated, oxygenated, carbonated, azoted, according to the excess of one or other of these four principles? I do not think chemical science is sufficiently advanced to authorize this mode of classification, and its adoption as the base of medical theory. We have neither observations sufficiently numerous, nor experiments sufficiently decisive to admit these notions as demonstrative truths. I even fear, that by these premature applications, we may compromise the fate of a science, which can only be of great utility when it is applied to the art of healing, with that prudence and reserve which the latter requires. Enthusiasm, and improper indulgence of the imagination, are no less detrimental to its progress, than the prejudices and opposition with which some persons resist the chemical discoveries which may really tend to its improvement.

7. It is by continuing to observe the effects and the symptoms of separate diseases, by neglecting

in the motions ; this state exists in hæmophysis, and in the beginnings of phthisis pulmonalis ; it is observed in many diseases. The whole system of the organs of the body is supposed to be equally super-oxygenated in this disposition. It is chiefly destroyed by the respiration of air, mixed with azote or carbonic acid gas. Venesection, aqueous drinks, strict diet, light aliment, are also very useful in it. The hidrogenated sulphurets form its specific remedy.

5. The cases in which there is a deficiency of oxygen, and in which hydrogen is admitted to be predominant, announce themselves by symptoms entirely the reverse of the former. The face has little colour ; the cheeks and lips are of a livid and violet cast ; the teeth dingy, and covered with tartar ; the breath fetid ; the motions slow and difficult. There is a general sensation of debility, which sometimes goes so far as to induce fainting ; the pulse is small and low, the respiration difficult ; the pulsations of the heart are irregular. This is the state of the body in the scurvy, in several chronical diseases ; it is in some sort a commencement, or first degree of asphyxia. Pure air, the acids, the oxidated metals, the acrid, bitter, tonic vegetables, are the remedies for this disposition. The oxygenated muriatic acid, the oxygenated muriate of pot-ash, the respiration of oxygen gas, or of air, with an addition of oxygen gas, are its specifics.

6. The

phates; and in the alkaline carbonate for the calcareous oxalate, may be employed with less uncertainty and better hopes than had been possible before our time. It will not be denied that the virulent and contagious diseases may become better known by chemical researches, both with respect to the nature of the virus, and to its destruction. The poisons afford still greater scope for chemical researches, and every one must acknowledge the advantage which this science affords in the knowledge and choice of counterpoisons. Let chemists continue to put nature to the question by the same means; let them pursue with ardour the career which is open to them; let them suffer no opportunity to escape for extending the applications of chemistry to the knowledge of diseases, not endeavouring to divine causes, but positively to ascertain effects; and the art of healing will gradually arrive at a degree of perfection and certainty which it has never yet approached.



FINIS.

A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE,
&c. &c.



A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,
Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.
TOGETHER WITH A SET OF SYNOPTIC TABLES IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,
BY WILLIAM NICHOLSON.

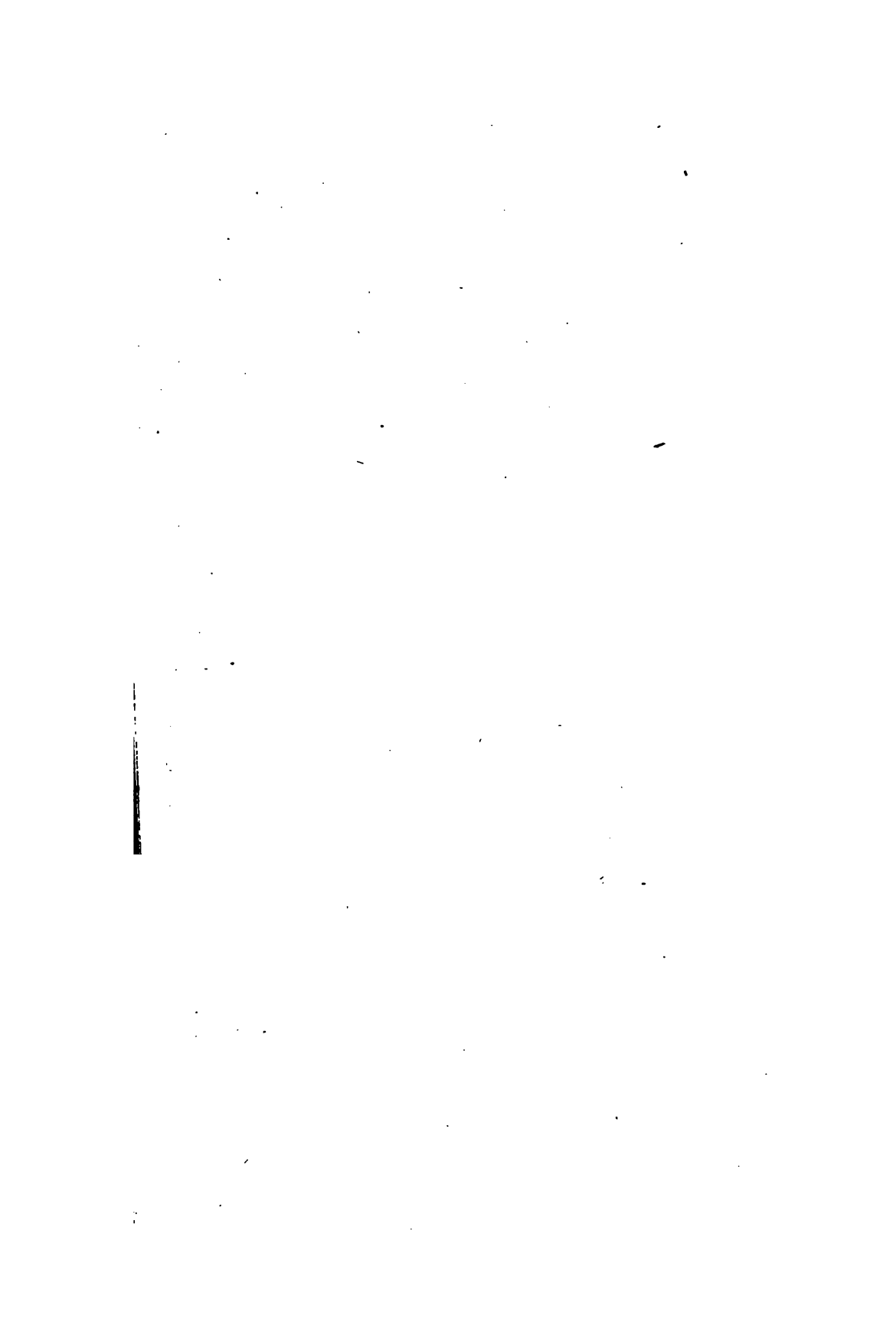
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